Enclosure 1
99-RF-02309

KAISER•HILL
COMPANY

Final
Solar Ponds Plume
Decision Document

RF/RMRS-98-286.UN

RMRS Rocky Mountain Remediation Services, L.L.C.
...protecting the environment

Environmental Restoration
Rocky Flats Environmental Technology Site

June 1999

1/79

Final
Solar Ponds Plume
Decision Document

RF/RMRS-98-286.UN

Major Modifications to the
Final Proposed Interim Measures/Interim Remedial Action
Decision Document for the Solar Evaporation Ponds
Operable Unit 4, 1992

Prepared by:

Rocky Mountain Remediation Services, L.L.C.

Revision 0
June 9, 1999

TABLE OF CONTENTS

1.0 INTRODUCTION **1**

1.1 Background 1

1.2 Purpose 3

2.0 PROJECT DESCRIPTION **4**

2.1 Conceptual Model 4
2.1.1 Geologic Setting 4
2.1.2 Hydrogeologic Setting 8
2.1.3 Surface Water Hydrology 8

2.2 Previous Investigations 8

2.3 Previous Actions 17

2.4 Recent Investigations and Evaluations 19
2.4.1 Well Installation 20
2.4.2 Groundwater Sampling Events 20
2.4.3 Vegetation Sampling 23
2.4.4 Soil Sampling for Agronomic Parameters 23
2.4.5 Hydrogeological Evaluations 27
2.4.6 Evaluation of Likely Sources of Uranium in SPP Groundwater 27

3.0 ALTERNATIVES EVALUATION/ ALTERNATIVES ANALYSIS **32**

3.1 Alternative Description 32
3.1.1 No Action 33
3.1.2 Managed Release of ITS Water 33
3.1.3 ITS Water Treatment at Building 995 33
3.1.4 Phytoremediation 34
3.1.5 Reactive Barrier 34

3.2 Groundwater Flow and Transport Model to Evaluate Remedial Alternatives 35

3.3 Alternatives Analysis 39

4.0 PROJECT OBJECTIVES **42**

5.0 PROPOSED APPROACH **43**

5.1 Reactive Barrier Design 43

3

5.2 Interceptor Trench System....46

5.3 Construction Water Management....46

5.4 Worker Health and Safety....46

5.5 Performance Monitoring....47

5.6 Air Monitoring....49

5.7 Waste Management....49

6.0 ENVIRONMENTAL EVALUATION.... 50

6.1 Soils and Geology....50

6.2 Air Quality....50

6.3 Water Quality....50

6.4 Human Health and Safety....51

6.5 Ecological Resources....51

6.6 Historic Resources....51

6.7 Visual Resources....51

6.8 Noise....51

6.9 Cumulative Effects....52

6.10 Unavoidable Adverse Effects....52

6.11 Short-term Uses Versus Long-Term Productivity....52

6.12 Irreversible and Irretrievable Commitments of Resources....52

7.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS.... 53

7.1 Chemical-Specific Requirements and Considerations....53
7.1.1 Colorado Water Quality Standards....53
7.1.2 National Emissions Standards for Hazardous Air Pollutants (NESHAP)....53

7.2 Action-Specific Requirements and Considerations....54
7.2.1 Remediation Waste....54
7.2.2 Identification and Listing of Hazardous or Toxic Substances Control Act Waste....54
7.2.3 Wastewater Treatment Unit....54
7.2.4 Land Disposal Restrictions....55
7.2.5 Construction Waters....55

4

7.2.6 Soil Staging 55
7.2.7 Temporary Unit Tank and Container Storage 55
7.2.8 Air Pollutant Emissions (Particulates, Volatile Organic Compounds, and Hazardous Air Pollutants) 55
7.2.9 Debris Treatment 56

7.3 Location Specific Requirements and Considerations 56
7.3.1 Endangered Species Act 56
7.3.2 Fish and Wildlife Coordination Act 57
7.3.3 Wetland Assessment 57

8.0 IMPLEMENTATION SCHEDULE 58

9.0 REFERENCES 59

APPENDIX A: ALTERNATIVE ANALYSIS

FIGURES

Figure 1-1. Site location map – Solar Ponds Plume. 2
Figure 2-1. Isopach of Unconsolidated Deposits and Weathered Bedrock and Approximate Location of Cross-Sections A-A' and B-B' – Solar Ponds Plume. 5
Figure 2-2. Cross-Section A-A'. 6
Figure 2-3. Cross-Section B-B'. 7
Figure 2-4. Extent of nitrate in the Upper Hydrostratigraphic Unit, Fall 1997/Winter 1998 10
Figure 2-5. Extent of uranium in the Upper Hydrostratigraphic Unit, Fall 1997/Winter 1998 11
Figure 2-6. Nitrate/nitrite yearly average concentration versus time at monitoring station SW095. 16
Figure 2-7. Total Uranium in the ITS vault (SW095) and linear regression. 17
Figure 2-8. Solar Evaporation Ponds and Interceptor Trench System. 18
Figure 2-9. 1997-1998 Sampling Locations – Solar Ponds Plume. 21
Figure 2-10. 1997-1998 Background and Walnut Creek Sampling Locations – Solar Ponds Plume 22
Figure 2-11. U-235/U-238 Ratio vs. U-236/U-238 Ratio. 31
Figure 3-1. Conceptual diagram of SPP Groundwater flow system and Model boundary locations 37
Figure 3-2. Location of Model Cross Section 38
Figure 5-1. Plan View of Treatment System. 44
Figure 5-2. Collection Trench Details. 45

TABLES

Table 2-1. Summary Of Phase I RFI/RI Surficial Soil Potential Contaminants Of Concern 13
Table 2-2. Summary of Subsurface Soil and Bedrock Analytical Results. 14
Table 2-3. Contamination Summary for SPP, 1995-1996 Data 15
Table 2-4. Summary of Wells and Analytes from 1997-1998 Sampling Events. 24
Table 2-5. Metals Results from May 1998 SPP Groundwater Sampling. 26
Table 2-6. Results of Vegetation Sampling. 26
Table 2-7. Uranium Isotope Mass from ICP/MS Analyses. 29
Table 2-8. Calculated Uranium Isotope Ratios from ICP/MS Data. 29

5

Table 3-1. Overall Comparison of Alternatives 41
Table 5-1. Schedule for Water Quality Sampling and Water Level Measurements. 48
Table 7-1. Big Dry Creek Segment 5 Surface Water Quality Standards. 53

ACRONYMS

AHA	Activity Hazard Analysis
ALF	Action Level Framework
APEN	Air Pollution Emission Notice
bgs	Below ground surface
ARAR	Applicable or relevant and appropriate requirement
BMP	Best Management Practice
CCR	Colorado Code of Regulations
CDPHE	Colorado Department of Public Health and Environment
CERCLA	Comprehensive Environmental, Compensation and Liability Act
CFR	Code of Federal Regulations
cfs	Cubic feet per second
DOE	Department of Energy
EDE	Effective Dose Equivalent
EPA	Environmental Protection Agency
gpm	Gallons per minute
HASP	Health and Safety Plan
IA	Industrial Area
ICP/MS	Inductively Coupled Plasma/Mass Spectroscopy
IMP	Integrated Monitoring Program
IM/IRA	Interim Measure/Interim Remedial Action
ITS	Interceptor Trench System
LANL	Los Alamos National Laboratory
LDR	Land Disposal Restrictions
mg/Kg	Milligram per kilogram
mg/L	Milligram per liter
mrem	Millirem
mrem/yr	Millirem per year
MST	Modular Storage Tanks
NESHAP	National Emissions Standards for Hazardous Air Pollutants
NEPA	National Environmental Policy Act
NPDES	National Pollution Discharge Elimination System
OU	Operable Unit
PA	Protected Area
PCB	Polychlorinated biphenyl
pCi/g	Picocurie per gram
pCi/L	Picocurie per liter
PPE	Personal Protective Equipment
RAAMP	Radioactive Ambient Air Monitoring Program
RCRA	Resource Conservation and Recovery Act
RACT	Reasonably Available Control Technologies
RFCA	Rocky Flats Cleanup Agreement
RFI/RI	RCRA Facility Investigation/Remedial Investigation

6

RFETS	Rocky Flats Environmental Technology Site
RFFO	Rocky Flats Field Office
SEP	Solar Evaporation Ponds
SPP	Solar Pond Plume
STP	Sewage Treatment Plant
μg/Kg	Microgram per kilogram
μg/L	Microgram per liter
UHSU	Upper Hydrostratigraphic Unit
USFWS	United States Fish and Wildlife Service
VOC	Volatile Organic Compound

1

1.0 INTRODUCTION

This document represents a major modification to the *Final Proposed Interim Measures/Interim Remedial Action (IM/IRA) Decision Document for the Solar Evaporation Ponds (SEP), Operable Unit (OU) 4* (DOE, 1992). The original IM/IRA was written as a result of an agreement among the Department of Energy, Rocky Flats Field Office (DOE RFFO), Colorado Department of Public Health and Environment (CDPHE), and Environmental Protection Agency (EPA) to address the issue of contaminated surface water in a portion of North Walnut Creek Drainage at the Rocky Flats Environmental Technology Site (RFETS). This Decision Document presents an evaluation of remedial alternatives and the proposed remedial action for managing the Solar Ponds Plume (SPP) to ensure protection of surface water. At present, water collected from the SPP by the Interceptor Trench System (ITS) is treated by flash evaporation at Building 374; however, the present collection system is not effective in capturing all contaminated groundwater flow from the SEPs (DOE, 1994). RFETS undertook a study to evaluate more cost-effective treatment technologies for the SPP (RMRS, 1997a). Although reducing the cost of treating the SPP water was the primary reason for identifying an alternative treatment method, the alternative is also a long-term solution/remediation for the SPP. Soil contamination in this area will be addressed as part of the Industrial Area OU.

In addition to presenting the proposed remedial action, this Decision Document presents the results of groundwater quality and hydrogeological evaluations of the SPP conducted in 1997 and 1998. This information supported alternative analyses and the selection of the proposed remedial action. Interception and treatment of the nitrate plume will mitigate a continuing source of contamination to North Walnut Creek. The SPP is ranked 16th on the 1998 Environmental Restoration Ranking List update to the Rocky Flats Cleanup Agreement (RFCA), Attachment 4.

1.1 Background

RFETS is a government-owned, contractor-operated facility formerly used for the fabrication of special nuclear materials for national defense. The 6,550-acre site is located in Jefferson County, Colorado, approximately 16 miles northwest of Denver (Figure 1-1). The cities of Boulder, Broomfield, Westminster, Golden, and Arvada are located less than 10 miles to the northwest, northeast, east, south, and southeast, respectively.

Centrally located within the RFETS boundary is a 400-acre security area called the Industrial Area (IA). A high security Protected Area (PA) is within the IA. The remaining 6,150 acres consist of undeveloped land used as a buffer zone to further limit access to the operations area (Figure 1-1). Fabrication operations began at the RFETS in 1951 and ceased in 1991 when the RFETS was placed into shut-down condition.

Operations at the site resulted in the generation of liquid and solid wastes containing radioactive and hazardous constituents that were managed in various waste processing units. The SEPs, located in the northeastern portion of the PA, were one of these waste-processing units (Figure 1-1). The SEPs were operated primarily to store and evaporate radioactive process wastes and neutralized acidic process wastes containing high levels of nitrate and aluminum hydroxide from 1953 to 1986. Leakage from the SEPs has contaminated the shallow groundwater in the area. The SPP has migrated down the hillside to the north of the SEPs and into North Walnut Creek.

8

In addition to the ITS constructed in 1981, the two IM/IRAs that initiated remediation at the SEPs also influenced the SPP. The *Final Proposed IM/IRA Decision Document for the SEPs, OU 4* (DOE, 1992) was approved in 1992 and included construction and utilization of three temporary storage tanks and associated piping to contain and transfer water collected by the ITS. The modular storage tanks (MSTs) are located on the hill to the northwest of the SEPs. At present, the water from the MSTs is transferred to Building 374 for flash evaporation. In 1995, the *Draft OU 4 IM/IRA Environmental Assessment Decision Document* for the SEPs was prepared (DOE, 1995). The action implemented by this document included the removal of liquid and sludges from the SEPs.

1.2 Purpose

This Decision Document outlines the remediation strategy, treatment goals, applicable regulatory requirements, and implementation schedule to accomplish a long-term and more cost-effective remedy for the SPP groundwater interception, management, and treatment. The SPP is currently being managed and treated according to the amended IM/IRA (DOE, 1992; DOE, 1995).

2.0 PROJECT DESCRIPTION

A brief description of the conceptual model for the project (Section 2.1) as well as a summary of previous investigations (Section 2.2), previous remedial actions (Section 2.3), and recent investigations and evaluations (Section 2.4) are provided in the following sections.

2.1 Conceptual Model

Components of the conceptual model include the geologic and hydrogeologic settings and surface water hydrology influencing the SPP.

2.1.1 Geologic Setting

RFETS is located between the Front Range to the west and the Denver Basin to the east. Since only Quaternary and Cretaceous deposits affect the SPP, other deposits were not discussed in this section. The Quaternary surficial deposits overlie the Cretaceous bedrock units (Arapahoe and Laramie Formations) and cover most of the ground surface at RFETS. These deposits vary in thickness across the site, and their physical characteristics control the groundwater recharge, near-surface flow, and contaminant migration within the units.

The Rocky Flats Alluvium is the most laterally extensive Quaternary deposit at RFETS and covers the plateau on which the SEPs were constructed. The Rocky Flats Alluvium is composed of clay, silt, sand, and heterogeneous pebbles, cobbles, and boulders. Artificial fill and colluvium are found together in the ITS area and to the southeast of the SEPs. Valley fill alluvium is composed of clay, silt, sand, and pebbly sand with silty and cobble gravel lenses and is found in the Walnut Creek drainage (DOE, 1995). Together, these deposits are referred to as "unconsolidated deposits" or "alluvium." Thickness of the unconsolidated deposits in the vicinity of the SEPs and SPP is shown on Figure 2-1 and ranges from 1 to 22.5 feet with the thickest areas of alluvium to the northeast (near well 46393) and southeast (near well P219489) of the SEPs (DOE, 1995).

The bedrock beneath the unconsolidated deposits in the SPP area is composed of claystone and silty claystone, with sandy siltstone and lenticular sandstone bodies. The claystones and siltstones are likely part of the Laramie Formation, while the sandstones are more likely part of the Arapahoe Formation. Claystone is the predominate lithology in the SPP area, although more permeable units (silty/sandy claystone, siltstone/sandy siltstone, and sandstone/clayey or silty sandstone) subcrop beneath the 207-C and 207-B ponds. Weathering-induced fractures and fracture fillings in bedrock claystones and siltstones have increased the permeability of these units and imparted an additional degree of friability to the coarser-grained sandstone units (DOE, 1995). The thickness of the weathered bedrock in the SPP area is shown on Figure 2-1. The competent bedrock underlying the weathered zone is relatively unfractured and generally contains little water. An inactive north-trending reverse fault has been postulated to run under the SEP 207-B ponds to North Walnut Creek and continue northward to join a northeast-trending fault approximately one mile to the north of the SEPs (Figure 2-1). Based on lithologic correlation, the displacement (not illustrated) along this fault varies from 50 feet at the southern end to 90 feet at the northern end (EG&G, 1995a; 1995b). The locations of Cross-Sections A-A' and B-B' are identified on Figure 2-1. Cross-sections A-A' and B-B' (Figures 2-2 and 2-3) illustrate the geology of the SPP area.

11

2.1.2 Hydrogeologic Setting

Groundwater flow enters the SEP area from the west-southwest in the upper hydrostratigraphic unit (UHSU) (unconsolidated deposits and weathered bedrock). Groundwater flows eastward beneath the SEPs and then diverges to the north-northeast toward North Walnut Creek and to the east-southeast toward South Walnut Creek (Figure 2-3). This divergence in groundwater flow is caused by an east-west trending bedrock high beneath the SEPs and natural topographic breaks in these directions (DOE, 1995). Localized fracturing in the claystone and siltstone, paleochannels, and the presence of the more permeable subcrops in the weathered bedrock provide potential preferential groundwater flow pathways for contaminant migration between the stratigraphic units. Two large bedrock channels in the Arapahoe Formation are present in the SEP area (Figure 2-3). The incised bedrock channels affect the flow of groundwater.

The groundwater flow path is very complex due to the varying thicknesses of the unconsolidated deposits and weathered bedrock units and the highly variable primary and secondary permeabilities of the two units. The combination of the varying thickness of the unconsolidated deposits and seasonal water table fluctuations result in large areas of the unconsolidated deposits in the ITS area becoming unsaturated. The hydraulic gradient between the unconsolidated deposits and weathered bedrock at the SEPs is downward, due to infiltration of rainfall at the ponds. Once the groundwater reaches the valley fill alluvium in the North Walnut Creek drainage, the hydraulic gradient appears to drive the groundwater upward from the weathered bedrock to the alluvium resulting in seeps along the hillside to the north of the SEPs (DOE, 1995).

Recharge and subsurface inflow to the SEP area originates from both natural and anthropogenic sources. Sources of recharge to the SPP include: natural groundwater flow entering the SEP area from the west and southwest, infiltration of precipitation on the SEPs and the ITS hillside, runoff from the PA directed to the ITS, and water used for dust suppression at the SEPs.

2.1.3 Surface Water Hydrology

The primary creeks in the immediate vicinity of the SPP are North and South Walnut Creeks and No Name Gulch. North Walnut Creek is located approximately 1,000 feet north of the SEPs and approximately 100 feet lower. The hillside extending from the SEPs northward to North Walnut Creek has a relatively uniform slope of 1:10. The surface topography to the north of North Walnut Creek rises steeply, similar to that observed on the south side of the Creek (See Figure 2-1). Flow in North Walnut Creek generally ranges from a low of approximately 0.007 cubic feet per second (cfs) in the summer and fall to a high of 5.05 cfs as measured in the spring at gauging station SW093, on the upstream edge of the SPP. The flow is managed via four water storage areas referred to as the A-Series Ponds. Pond A-1 is the closest to the SPP and Pond A-4 is closest to the RFETS eastern boundary. South Walnut Creek begins approximately 1,000 feet southeast of the SEPs. Flow in South Walnut Creek is managed via the B-Series Ponds. North and South Walnut Creeks and No Name Gulch join to form Walnut Creek downstream of Pond A-4. Nitrate concentrations at SW093 generally range from 1 to 2 milligrams per liter (mg/L) and uranium activities (all isotopes combined) range from approximately 4 to 6 picocuries per liter (pCi/L).

2.2 Previous Investigations

Previous investigations have been conducted to characterize the SEPs and nature and extent of contamination associated with the SPP. Operational history of the SEPs is contained within these

15

references. As stated in Section 1.1, studies to evaluate the effectiveness of the ITS have also been conducted. These investigations/studies are detailed in the following:

- *OU4—SEPs, IM/IRA Environmental Assessment Decision Document*, U.S. DOE, RFETS, February, 1995 (DOE, 1995)
- *Final Phase II Resource Conservation and Recovery Act (RCRA) Facility Investigation/Remedial Investigation (RFI/RI) Work Plan, OU4, SEPs*; RF/ER-94-00040, U.S. DOE, RFETS, September 1994 (DOE, 1994)
- *OU4 SEPs, Phase II Ground Water Investigation, Final Field Program Report*, ERM, February 1996 (ERM, 1996)
- *Management Plan for the ITS Water*, RF/ER-96-0031.UN, Rocky Mountain Remediation Services (RMRS, 1996)
- *SPP Remediation and ITS Water Treatment Study*, RF-RMRS-97-093.UN, Rocky Mountain Remediation Services (RMRS, 1997a).

From these investigations/studies, it is known that the SPP is contained within the UHSU. The primary contaminants in the plume are uranium and nitrate, although other metals have also been detected above background groundwater concentrations. However, an analysis of metals distribution was conducted and indicates there is no metals plume associated with the Solar Ponds. The nitrate plume extends from the vicinity of the SEPs, for approximately 1,400 feet in a northeastward direction to North Walnut Creek, and approximately 1,400 feet to the southeast and east toward South Walnut Creek (Figure 2-4). Available data indicate that the uranium plume is primarily limited to the plateau where the SEPs are located, although it may extend into the ITS (Figure 2-5). The portion of the SPP containing the highest nitrate concentrations extends from the northern portion of the SEPs in a northeasterly direction to North Walnut Creek. Nitrate concentrations in the SEP area range from 0.06 mg/L to the east of Pond 207-B Center to 5,400 mg/L to the north of SEP 207-B North. In the North Walnut Creek drainage, nitrate concentrations range from 640 mg/L at the eastern end of the SPP to 0.06 mg/L at the eastern end of the SEPs (Figure 2-4). Nitrate concentrations downgradient of the ITS appear to be a combination of historical and current flow, and cannot be attributed solely to groundwater flow prior to installation of the ITS (RMRS, 1997a). The highest total uranium isotope activity concentrations (total of all dissolved uranium isotope activities) are found near the center of the SEPs and range from 655 pCi/L to 1,605 pCi/L (Figure 2-5).

The portion of the SPP migrating toward South Walnut Creek has not impacted surface water quality of the drainage. Results from surface water monitoring station GS10 indicate that nitrate has never exceeded 10 mg/L with a maximum concentration observed of 5.7 mg/L in 1994. As stated above, the uranium plume is limited to the plateau. The maximum uranium activity (all activities combined) observed at GS-10 was 6.7 pCi/L in 1992.

Tables 2-1 and 2-2 summarize surficial and subsurface soil data from previous investigations. Table 2-3 summarizes SPP groundwater analytical results that exceeded the Tier I or Tier II groundwater action levels or the North Walnut Creek surface water action level. Low concentrations of volatile organic compounds (VOCs) (i.e., chloroform, carbon tetrachloride, trichloroethene, and tetrachloroethene) have

16

Table 2-1. Summary Of Phase I RFI/RI Surficial Soil Potential Contaminants Of Concern.

Chemical	Units	No. Of Samples Analyzed	No. of Detects	Percentage Of Detects	Minimum Detection	Counting Error	Maximum Detection	Counting Error	Background 95% UCL	No of Detections >95% UCL	Percentage Of Samples >95% UCL
AMERICIUM-241	pCi/g	72	70	97.2	0.028	0.016	220	54	0.027	70	98.6
CESIUM-134	pCi/g	57	19	33.3	-0.067	0.0319	0.033	0.0262	NA	--	--
GROSS ALPHA	pCi/g	72	65	90.3	8.561	3.27	440	14	22.9	31	43.1
PLUTONIUM-239/240	pCi/g	72	60	83.3	0.0101	0.0108	56	10	0.062	52	73.2
TRITIUM	pCi/g	72	47	65.3	-59.5	215	227,000	23,000	NA	--	--
URANIUM-233,-234	pCi/g	72	72	100.0	0.457	0.149	41	3.4	1.22	38	52.8
URANIUM-235	pCi/g	72	63	87.5	0.0191	0.0296	2.3	0.28	0.09	26	36.1
URANIUM-238	pCi/g	72	72	100.0	0.515	0.16	27	2.3	1.27	31	43.1
BERYLLIUM	mg/Kg	72	11	15.3	1.5		9.6		0.92	11	15.3
CADMIUM	mg/Kg	72	37	51.4	1.3		382		0.64	37	51.4
CALCIUM	mg/Kg	72	72	100.0	1110		248,000		8,283	39	54.2
MERCURY	mg/Kg	72	20	27.8	0.07		1.8		0.03	18	25.0
NITRATE/NITRITE	mg/Kg	72	72	100.0	0.66		765		1.11	67	93.1
SILICON	mg/Kg	72	72	100.0	463		11,300		1,111.2	72	100.0
SILVER	mg/Kg	72	5	6.9	1.3		3.6		0.58	5	6.9
SODIUM	mg/Kg	72	12	16.7	378		2,440		165.4	12	16.7
BENZO(a)ANTHRACENE	µg/Kg	72	47	65.3	38		1,900		NA	--	--
BENZO(a)PYRENE	µg/Kg	72	51	70.8	36		2,100		NA	--	--
BENZO(b)FLUORANTHENE	µg/Kg	72	57	79.2	32		3,300		NA	--	--
BENZO(ghi)PERYLENE	µg/Kg	72	37	51.4	15		1,300		NA	--	--
BENZO(k)FLUORANTHENE	µg/Kg	72	58	80.6	32		3,700		NA	--	--
BIS(2-ETHYLHEXYL)PHTHALAT	µg/Kg	72	57	79.2	42		21,000		NA	--	--
CHRYSENE	µg/Kg	72	49	68.1	36		2,200		NA	--	--
DI-n-BUTYL PHTHALATE	µg/Kg	72	30	41.7	36		1,700		NA	--	--
FLUORANTHENE	µg/Kg	72	59	81.9	40		4,700		NA	--	--
INDENO(1,2,3-c,d)PYRENE	µg/Kg	72	42	58.3	42		1,600		NA	--	--
PHENANTHRENE	µg/Kg	72	31	43.1	37		3,700		NA	--	--
PYRENE	µg/Kg	72	59	81.9	48		3,600		NA	--	--
AROCLOR-1254	µg/Kg	72	6	8.0	282		11,900		NA	--	--

Notes: 95% UCL – 95% Upper Confidence Limit calculated from data in the 1993 Background Geochemical Characterization Report is defined as background; NA – Not Analyzed

Table 2-2. Summary of Subsurface Soil and Bedrock Analytical Results.

Chemical	Units	No. Of Samples Analyzed	No. of Detects	Percentage Of Detects	Minimum Detection	Counting Error	Maximum Detection	Counting Error	Background 95% UCL	No of Detections >95% UCL	Percentage Of Samples >95% UCL
BARIUM	mg/Kg	136	136	100.0	9.7		4150		93.87	51	37.5
CADMIUM	mg/Kg	136	28	20.6	1.1		547		2.30	25	18.4
CALCIUM	mg/Kg	136	136	100.0	706		328,000		7,782	67	49.3
CYANIDE	mg/Kg	94	18	19.2	0.525		43		NA	--	--
LITHIUM	mg/Kg	136	134	98.5	2.6		79.9		83.20	0	0.0
MANGANESE	mg/Kg	136	136	100.0	27.4		3140		190.50	38	27.9
NITRATE/NITRITE	mg/Kg	111	110	99.1	0		6100		7.10	72	64.9
POTASSIUM	mg/Kg	136	136	100.0	180		21100		1,563	70	51.5
SODIUM	mg/Kg	136	70	51.5	139		10,200		2,720	18	13.2
SULFIDE	mg/Kg	93	9	9.7	12.7		18.6		43,000	0	0.0
ZINC	mg/Kg	136	136	100.0	7.2		168		23.64	78	57.4
AMERICIUM-241	pCi/g	96	78	81.3	0.0017	0.0024	6.1	0.72	0.01	50	52.1
CESIUM-134	pCi/g	90	49	54.4	-0.0013	0.0101	0.0123	0.0122	NA	--	--
CESIUM-137	pCi/g	96	91	94.8	-0.0378	0.0177	0.42	0.15	0.166	3	3.1
GROSS BETA	pCi/g	134	134	100.0	10	3.7	55	5.7	27.99	51	38.1
PLUTONIUM-239/240	pCi/g	96	78	81.3	-0.0028	0.00328	25	2.9	0.02	37	38.5
RADIUM-226	pCi/g	94	82	87.2	0.37	0.21	6.838	0.92	0.65	59	62.8
STRONTIUM-89,90	pCi/g	96	66	68.8	0.0139	0.0276	0.88	0.26	0.54	12	12.5
TRITIUM	pCi/g	133	115	86.5	63.97	218	62,000	1300	212.2	102	76.7
URANIUM-233,-234	pCi/g	134	133	99.3	0.242	0.107	21	3.1	0.53	125	93.3
URANIUM-235	pCi/g	134	122	91.0	-0.0104	0.0208	0.87	0.27	0.1	33	24.6
URANIUM-238	pCi/g	134	133	99.3	0.39	0.134	11.46	1.81	0.63	123	91.8
ACETONE	µg/Kg	146	38	26.0	8		140		NA	--	--
BIS(2-ETHYLHEXYL) PHTHALATE	µg/Kg	36	8	22.2	38		5,300		NA	--	--
METHYLENE CHLORIDE	µg/Kg	146	74	50.7	1		71		NA	--	--
TOLUENE	µg/Kg	146	145	99.3	2		1,200		NA	--	--

Notes: 95% UCL calculated from data presented in 1993 Background Geochemical Characterization Report (EG&G, 1993); NA – Chemical not analyzed in background samples

20

Table 2-3. Contamination Summary for SPP, 1995-1996 Data.

Dissolved Metal	Detections	Minimum Conc.	Maximum Conc.	Average Conc.	Action Levels Exceeded	Groundwater Tier I Action Levels	Groundwater Tier II Action Levels	Groundwater Background MS2D	Surface Water N. Walnut Creek Action Levels	Surface Water Background MS2D
Aluminum (µg/L)	5	20.1	372	103.4	SW	10,600,000	36500	234.1	87*	420.6*
Antimony (µg/L)	11	2.1	9.5	3.8	SW, Tier II	600	6	39.54	6	34.98
Cadmium (µg/L)	5	3	5	4.1	SW	500	5	4.25	1.5*	3.08*
Copper (µg/L)	17	1.7	26.8	8.9	SW	130000	1300	13.85	16*	15.84*
Lithium (µg/L)	117	4.1	1740	209.4	Tier II	73000	730	142.55	---	46.61
Manganese (µg/L)	43	0.69	348	45.4	Tier II	18300	1720	162.33	1000	771.9
Mercury (µg/L)	8	0.04	0.82	0.26	SW	200	2	0.25	0.01	0.41
Nickel (µg/L)	20	4.2	321	70.7	SW, Tier II	10000	100	21.37	123*	18.61*
Selenium (µg/L)	90	3	1510	107.6	SW, Tier II	5000	50	43.72	5*	9.5*
Silver (µg/L)	4	3	5.6	4.45	SW	18300	183	7.08	0.6*	8.16*
Thallium (µg/L)	28	4.6	26.1	10.6	SW, Tier II	200	2	4.9	0.5	6.08
Nitrate/Nitrite (mg/L)		0.01	5200	354.8	SW, Tier II	10000	100		10	1.2
U-234 (pCi/L)	142	0.200	242.7	30.57	Tier I, Tier II	10.7	1.07		---	1.59
U-238 (pCi/L)	142	-0.059	105.20	18.9	Tier I, Tier II	76.8	0.768		---	1.22
U-Total (pCi/L)	138	0.26	364	50.6	SW	---	---		10	1.63

--- = Not Applicable
* = dissolved

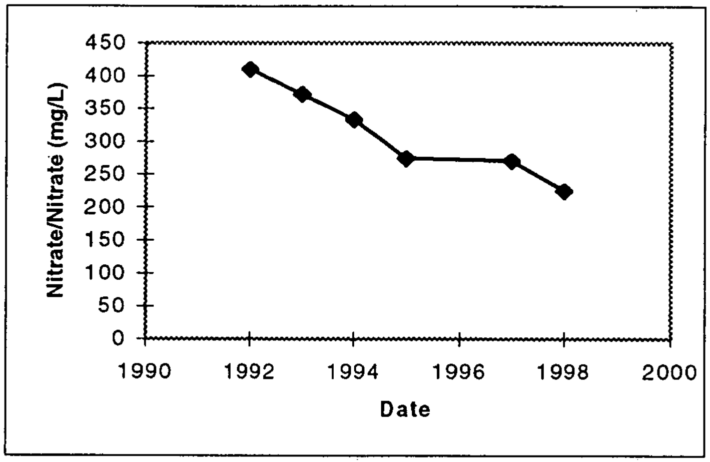
Conc. = concentration
MS2D = mean plus two standard deviations
SW = surface water action level
Tier II, Tier I = Groundwater action levels

21

been identified in the SPP groundwater; however, in general the concentrations of VOCs in the SPP on the northern side of the SEPs do not exceed RFCA Tier II concentrations or are non-detects. These were not included in the contamination summary because the apparent source of VOC contamination is upgradient of the SEPs. Several metals (including selenium and thallium) exceed the site groundwater action levels set forth in RFCA (DOE, 1996).

Monitoring station SW095, located at the ITS pump house (Figure 2-4), allows sampling of the water collected by the ITS. The contaminants that have been monitored are nitrate/nitrite and uranium isotopes. One to four samples representative of the nitrate/nitrite concentrations in the ITS during previous low flow seasons were collected each year between 1992 and 1998. The resulting nitrate/nitrite yearly average concentrations show a consistent downward trend at SW095 over the last six years (Figure 2-6). The maximum nitrate/nitrite concentration recorded at SW095 was 440 mg/L in 1992. The decrease in nitrate/nitrite concentration corresponds with the removal of sludges and liquids from the SEPs during the 1993 to 1995 time period and is possibly attributed to the removal. Removal of the sludges and liquid removed the source of contamination and also reduced the hydraulic head which is believed to have accelerated contamination migration into the unconsolidated materials underlying the SEPs.

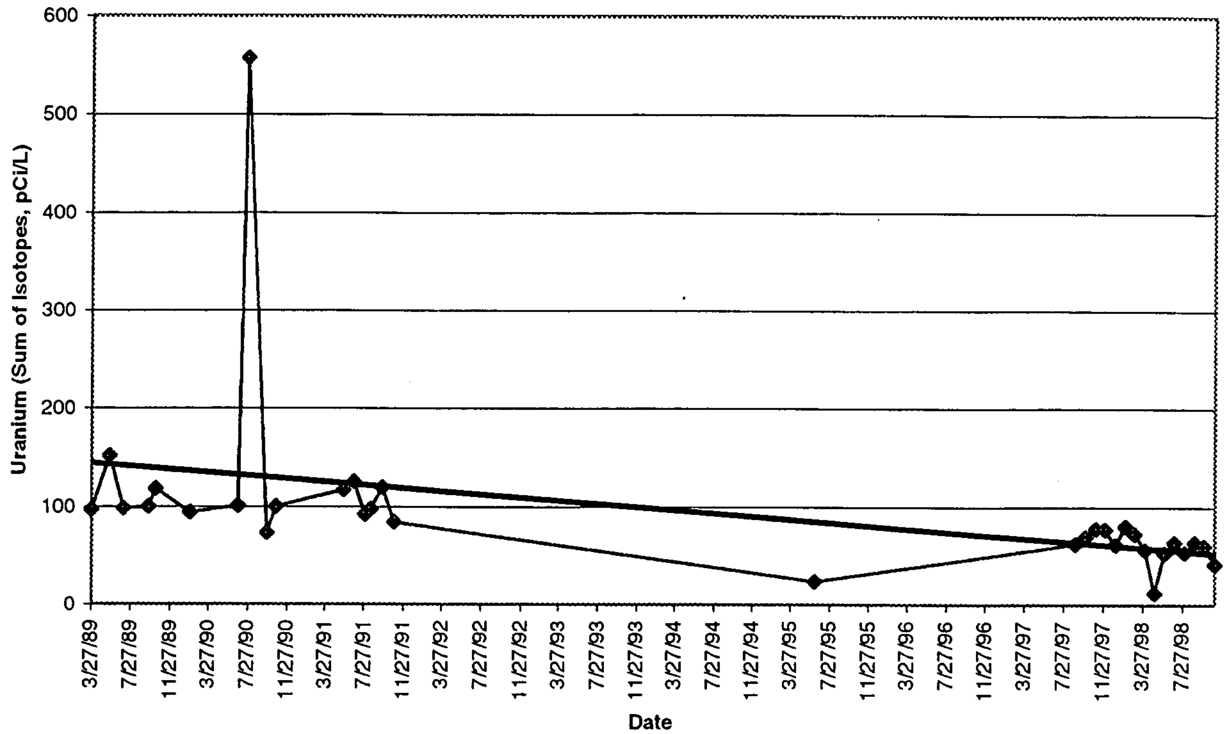
Figure 2-6. Nitrate/nitrite yearly average concentration versus time at monitoring station SW095.



Samples of water collected by the ITS are generally not collected during the high flow season primarily because the resulting nitrate/nitrite concentrations are substantially lower than those collected during low flow season due to dilution by infiltration of precipitation to the system.

Since nitrate/nitrite concentrations have been the primary concern regarding the ITS water, fewer samples were analyzed for uranium isotopes. Five samples from SW095 were analyzed for uranium isotopes in 1989, three in 1990, one in 1991, one in 1995, four in 1997 and three in 1998. The stream standard for uranium in North Walnut Creek is based on total uranium activity. Consequently, the uranium isotope activities from each sample were totaled and an average for each year with multiple samples was obtained. These data are illustrated in Figure 2-7 and show a downward trend similar to that observed for nitrate/nitrite.

Figure 2-7. Total Uranium in the ITS vault (SW095) and linear regression.



*The activity of the one sample from 1995 is much lover than the other samples because it represents a high flow event, whereas the other samples represent averages of low flow events.

2.3 Previous Actions

Between 1970 and 1974, six trenches were installed on the hillside to the north of the SEPs to collect leakage from the SEPs. Collection of pond leakage was implemented to decrease the volume of high nitrate groundwater discharging to North Walnut Creek and increase slope stability. Water collected from these trenches was pumped back to Pond 207-B North.

The original trenches were abandoned in place and an expanded trench system of french drains was installed in 1981 and is still in use today (Figure 2-8). Water collected by the ITS flows by gravity to the pump house located near North Walnut Creek. Until 1993, water collected by the ITS continued to be recycled to Pond 207-B North. In 1993, three 750,000-gallon MSTs were installed on a hillside on the north side of North Walnut Creek. Water is temporarily stored in the MSTs and then pumped to Building 374 for evaporation.

The depth of the french drains comprising the ITS ranges from 1 to 27 feet below ground surface (bgs), with typical depths of 4 to 15 feet bgs (EG&G, 1994). The gravel-filled trenches are approximately 1- foot wide, with perforated pipe in the bottom to intercept and transport groundwater flow to the ITS pump house. The trenches are covered with topsoil at the surface to minimize the collection of storm water runoff and allow for vegetative growth.

RMRS (1996) proposed to discontinue treatment of the ITS water in Building 374. The proposed actions used a phased approach in the management of ITS water. These phases included:

- Phase I: Cessation of treatment and transport of ITS water directly to Pond A-4, the final point of discharge of surface water from the site
- Phase II: Direct release of ITS water into North Walnut Creek drainage
- Phase III: Complete decommissioning of the ITS

A detailed evaluation of site hydrology, surface water flows and water quality, and the impact of ITS water was conducted. A computer spreadsheet model was developed to simulate water quality at points of compliance under the proposed phases of ITS management. Using flow and water quality results for North Walnut Creek for the period October 1, 1992 through February 29, 1996, predicted seasonal average flow values and predicted seasonal average concentrations of nitrate and total uranium activities were calculated for North Walnut Creek for each phase. The results of each phase indicated that the seasonal average nitrate concentrations and uranium activities would meet the applicable stream standards at the points of compliance. However, actual discrete water-quality measurements were expected to vary over time. During periods of low influent surface water flows, resultant water quality in North Walnut Creek would approach the water quality of the ITS water. Therefore, actual maximum and minimum North Walnut Creek water quality would depend strongly on the future quantity and quality of both the ITS and North Walnut Creek.

2.4 Recent Investigations and Evaluations

Recent investigations and evaluations focused on gathering the information necessary to determine a long-term cost-effective remedial alternative for the SPP. Data from previous investigations were reviewed and discrepancies between the data and previous interpretations of areas keyed to bedrock were observed. These observations prompted a more detailed review of the geologic data in the SPP area including data collected since 1994. The results of the review indicate the lithologic units in the ITS area are substantially more heterogeneous than previously thought and precluded an accurate assessment of the effectiveness of the current ITS system (Grigsby, 1998). However, it is apparent from the downgradient water quality that some groundwater affected by contaminant infiltration from the SEPs is not being captured by the current ITS.

Data gaps regarding the nature and extent of the SPP, local hydrogeology, agronomic properties of SPP soil, and uranium uptake by deep-rooting vegetation were identified with respect to the selection of a remedial action technology and were addressed during recent investigations (RMRS 1997c; RMRS 1997c; RMRS 1997d). The data gaps were as follows:

- Definition of current vertical and lateral extent of the SPP (nitrate and uranium)
- Refinement of the conceptual hydrogeological model

25

- Use of analytical models to simulate local groundwater flow and predict the concentrations of nitrate and uranium in the groundwater that will discharge to North Walnut Creek under various scenarios
- Evaluation of the uranium uptake of vegetation presently in the SPP and comparison of these data to background data
- Evaluation of agronomic properties of soils in the ITS area where a phytoremediation system may be placed
- Evaluation of uranium isotopic ratios of groundwater samples from the SPP and background locations for identifying locations where uranium in groundwater can be attributed to leakage from the Solar Ponds
- Treatability studies of ITS water at Building 995 and evaluation of uranium content of biosolids

The field investigations were conducted from October 1997 through May 1998 and included well installation, groundwater sampling and analysis, vegetation sampling, and soil sampling for agronomic parameters. The results were used to refine the alternative evaluation and assess the hydrogeological conditions.

2.4.1 Well Installation

Two areas where additional groundwater data were needed, to the north of the SEPs near North Walnut Creek and to the southeast of SEP 207B-South in the South Walnut Creek drainage, were identified in the OU 4 Phase II Groundwater Investigation Report (ERM, 1996). In February 1998, a GeoProbe™ was used to install four wells in these areas. One well (03498) was installed to the north of the SEPs and three wells (03198, 03298, and 03398) were installed to the southeast of the SEPs (Figure 2-9). Well 03198 was dry, but the other three wells contained sufficient water for analyses.

2.4.2 Groundwater Sampling Events

The primary objective of the groundwater sampling was to determine the nature and extent of the SPP (nitrate/nitrite and uranium) in the unconsolidated deposits, weathered bedrock, and competent bedrock during the low-flow (late fall/early winter) and high-flow seasons (spring). A secondary objective was to evaluate the amount and distribution of naturally occurring uranium present in the SPP groundwater. Two sampling events were conducted to accomplish these objectives. Ninety wells were included in the first (low-flow) sampling event, which took place from November 1997 through February 1998. The samples collected during the low-flow event were analyzed for a combination of nitrate/nitrite, uranium isotopes, and VOCs. Details of the sampling program are provided in *Sampling and Analysis Plan for Groundwater Sampling and Well Installation in the SPP Area, RF/RMRS-97-136*, February 1997 (RMRS, 1997b). Sampling locations are presented on Figures 2-9 and 2-10.

Seven wells were included in the second, limited (high-flow) event, which took place in May 1998. The wells were selected to represent the different parts of the SPP, as well as the unconsolidated and weathered bedrock units of the UHSU. The samples collected during the high-flow event were analyzed

26

for nitrate/nitrite, uranium isotopes, and metals. Table 2-4 summarizes the types of wells sampled and the analytes for each sampling event. The results of these sampling events are presented on Figures 2-4 and 2-5 and summarized on Table 2-5. The metals results are shown on Table 2-5. Only manganese and selenium exceeded a groundwater or surface water action level in these samples.

2.4.3 Vegetation Sampling

Samples of trees and grasses were collected in November 1997 from two drainages (North Walnut Creek, within the SPP and Lindsey Ranch in the Rock Creek drainage--considered background). The samples were analyzed for uranium isotopes to determine if there was detectable uranium uptake into the plants from the groundwater and any differences in uptake between the locations between the vegetation types or between plant tissues (leaves vs. woody materials). Leaves and branches of cottonwood trees were collected from two trees at the North Walnut Creek location (see Figure 2-9) and one tree at Lindsey Ranch (See Figure 2-10); grasses were collected from nine locations along a 100-foot transect at each site. Details of the sample collection and analysis were presented in the *Sampling and Analysis Plan for Vegetation in the Area of the SPP* (RMRS, 1997c). This effort was an initial screening to determine if there were sufficient levels of uranium in plant materials to warrant additional testing.

The results of the uranium isotopic analyses of the vegetation samples are shown in Table 2-6. Activities in plant materials ranged from 0.008 to 0.159 pCi/g. There is an apparent difference in the uranium activities between the cottonwood leaves at the two locations. The leaves at the North Walnut Creek location contained approximately six times more uranium than the leaves at the Lindsey Ranch location. The results for the grasses and cottonwood branches appear to be essentially the same at both locations, although the limited number of samples precludes a rigorous comparison between the results at the two locations. These results indicate that while uranium uptake by plant materials does occur at RFETS, it does not appear likely that cottonwood trees and grasses (the most common vegetation in the SPP area) would concentrate uranium from soils and groundwater and disperse this uranium during fall leaf drop.

2.4.4 Soil Sampling for Agronomic Parameters

To assess the viability of phytoremediation as a remedial alternative additional information regarding agronomic conditions of the soil in these areas was necessary. Two transects were constructed: one traversing approximately 900 feet of the plume area and a second of approximately 275 feet, perpendicular to the first, through the most concentrated portion of the SPP. A GeoProbe™ was used to drill five, 8-foot deep boreholes at the locations shown on Figure 2-9.

Two samples, representing the upper and lower portions of the borehole, were collected and analyzed for the following parameters:

- Soil texture (field and laboratory methods)
- Standard soil tests (organic matter, pH, electrical conductivity, cation exchange capacity)
- Available nutrients (phosphorous, potassium, nitrogen species, sulfur, magnesium, calcium, sodium, iron, aluminum, manganese, copper, zinc)
- Uranium

Table 2-4. Summary of Wells and Analytes from 1997-1998 Sampling Events.

Well Type	Unit Screened	Well Number	Analyte Suite-First Event	Analyte Suite-Second Event
Background	Unconsolidated Deposits	5586	U(A)	Not Sampled
Background	Unconsolidated Deposits	10294	NO3, U(A)	Not Sampled
Background	Unconsolidated Deposits	5386	Dry	Not Sampled
Background	Unconsolidated Deposits	B102289	U(A), U(ICP)	Not Sampled
Background	Unconsolidated Deposits	B200589	U(A)	Not Sampled
Background	Unconsolidated Deposits	B202589	U(A)	Not Sampled
Background	Unconsolidated Deposits	B205589	U(A), U(ICP)	Not Sampled
Background	Unconsolidated Deposits	B302789	U(A), U(ICP)	Not Sampled
Background	Weathered Bedrock	B201589	U(A), U(ICP)	Not Sampled
Background	Weathered Bedrock	B203189	U(A), U(ICP)	Not Sampled
Background	Weathered Bedrock	B203489	U(A)	Not Sampled
Background	Weathered Bedrock	B305389	U(A), U(ICP)	Not Sampled
Background	Weathered Bedrock	B405489	U(A), U(ICP)	Not Sampled
Background	Bedrock	B304989	U(A)	Not Sampled
South Walnut Creek	Unconsolidated Deposits	75992	NO3, U(A)	Not Sampled
South Walnut Creek	Unconsolidated Deposits	75292	U(A)	Not Sampled
North Walnut Creek	Unconsolidated Deposits	10594	U(A)	Not Sampled
North Walnut Creek	Unconsolidated Deposits	10694	U(A)	Not Sampled
North Walnut Creek	Unconsolidated Deposits	P114389	NO3, U(A)	Not Sampled
New Well, SPP	Unconsolidated Deposits	03498	Dry	Not Sampled
SPP	Unconsolidated Deposits	1586	NO3, U(A), U(ICP)	Not Sampled
SPP	Unconsolidated Deposits	2286	NO3, U(A)	Not Sampled
SPP	Unconsolidated Deposits	2686	NO3, U(A)	Not Sampled
SPP	Unconsolidated Deposits	3887	NO3, U(A)	Not Sampled
SPP	Unconsolidated Deposits	5687	NO3, U(A)	Not Sampled
SPP	Unconsolidated Deposits	29795	Dry	Not Sampled
SPP	Unconsolidated Deposits	41193	NO3, U(A)	Not Sampled
SPP	Unconsolidated Deposits	45093	NO3, U(A)	Not Sampled
SPP	Unconsolidated Deposits	45393	NO3, U(A)	Not Sampled
SPP	Unconsolidated Deposits	45793	Dry	Not Sampled
SPP	Unconsolidated Deposits	46293	NO3, U(A)	Not Sampled
SPP	Unconsolidated Deposits	46393	NO3, U(A)	Not Sampled
SPP	Unconsolidated Deposits	P209789	NO3, U(A)	Not Sampled
SPP	Unconsolidated Deposits	05093	NO3, U(A)	Not Sampled
SPP	Unconsolidated Deposits	05193	NO3, U(A)	Not Sampled
SPP	Unconsolidated Deposits	05293	NO3, U(A)	Not Sampled
SPP	Unconsolidated Deposits	1386	NO3, U(A)	Not Sampled
SPP	Unconsolidated Deposits	1786	NO3, U(A)	NO3, U(A), METALS
SPP	Unconsolidated Deposits	B208589	NO3, U(A)	Not Sampled
SPP	Unconsolidated Deposits	B208789	NO3, U(A)	Not Sampled
SPP	Unconsolidated Deposits	B210489	NO3, U(A)	NO3, U(ICP), METALS
SPP	Unconsolidated Deposits	P207889	NO3, U(A)	Not Sampled
SPP	Unconsolidated Deposits	P218389	NO3 *	Not Sampled
SPP	Unconsolidated Deposits	P207689	NO3, U(A)	Not Sampled
Upgradient of SPP	Unconsolidated Deposits	P209289	VOC	Not Sampled
SPP	Unconsol./Weathered Bed.	41693	NO3, U(A)	Not Sampled
SPP	Unconsol./Weathered Bed.	41993	NO3, U(A), VOC	Not Sampled

Best Available Copy

30

Table 2-4 (continued).

Well Type	Unit Screened	Well Number	Analyte Suite-First Event	Analyte Suite-Second Event
SPP	Unconsol./Weathered Bed.	43293	Dry	Not Sampled
SPP	Unconsol./Weathered Bed.	43593	NO3, U(A)	Not Sampled
SPP	Unconsol./Weathered Bed.	43893	NO3, U(A), VOC	Not Sampled
SPP	Unconsol./Weathered Bed.	43993	NO3, U(A), VOC	NO3, U(ICP), METALS
SPP	Unconsol./Weathered Bed.	45893	NO3, U(A), VOC	Not Sampled
SPP	Unconsol./Weathered Bed.	45993	Dry	Not Sampled
New Well, SPP	Weathered Bedrock	03198	NO3, U(A)	Not Sampled
New Well, SPP	Weathered Bedrock	03298	NO3 *	Not Sampled
New Well, SPP	Weathered Bedrock	03398	NO3, U(A)	Not Sampled
SPP	Weathered Bedrock	3086	NO3, U(A)	Not Sampled
SPP	Weathered Bedrock	23995	Dry	Not Sampled
SPP	Weathered Bedrock	26995	Dry	Not Sampled
SPP	Weathered Bedrock	28295	NO3, U(A)	Not Sampled
SPP	Weathered Bedrock	29395	VOC *	Not Sampled
SPP	Weathered Bedrock	30595	NO3, U(A), VOC	Not Sampled
SPP	Weathered Bedrock	30695	Dry	Not Sampled
SPP	Weathered Bedrock	45693	NO3, U(A), VOC	Not Sampled
SPP	Weathered Bedrock	46193	NO3, U(A)	Not Sampled
SPP	Weathered Bedrock	76292	NO3, U(A)	Not Sampled
SPP	Weathered Bedrock	02691	NO3, U(A)	Not Sampled
SPP	Weathered Bedrock	05393	NO3, U(A)	Not Sampled
SPP	Weathered Bedrock	B208689	NO3, U(A)	NO3, U(ICP), METALS
SPP	Weathered Bedrock	B210389	NO3, U(A)	Not Sampled
SPP	Weathered Bedrock	P207989	NO3, U(A)	Not Sampled
SPP	Weathered Bedrock	P208989	NO3, U(A)	Not Sampled
SPP	Weathered Bedrock	P209089	NO3, U(A)	Not Sampled
SPP	Weathered Bedrock	P209189	NO3, U(A), U(ICP), VOC	Not Sampled
SPP	Weathered Bedrock	P209489	NO3, U(A), VOC	NO3, U(ICP), METALS
SPP	Weathered Bedrock	P209589	NO3, U(A),U(ICP)	Not Sampled
SPP	Weathered Bedrock	P209889	NO3, U(A)	NO3, U(ICP), METALS
SPP	Weathered Bedrock	P210089	NO3, U(A)	Not Sampled
SPP	Weathered Bedrock	P210189	NO3, U(A), VOC	Not Sampled
SPP	Weathered Bedrock	P219589	NO3, U(A)	Not Sampled
SPP	Bedrock	1486	NO3, U(A)	Not Sampled
SPP	Bedrock	1686	NO3, U(A)	Not Sampled
SPP	Bedrock	2386	NO3, U(A)	Not Sampled
SPP	Bedrock	2586	NO3, U(A)	Not Sampled
SPP	Bedrock	2786	NO3, U(A)	Not Sampled
SPP	Bedrock	3286	NO3, U(A)	Not Sampled
SPP	Bedrock	3987	NO3, U(A)	Not Sampled
SPP	Bedrock	P208889	NO3, U(A)	Not Sampled

NOTES
RFCA Wells = Shaded
First Event = Fall 1997/Winter 1998 (Low-Flow)
Second Event = May 1998 (High-Flow)
* = Not enough water for other analytes

ANALYTE CODES
NO3 = Nitrate/Nitrite
U(A) = Uranium Isotopes by Alpha Spectroscopy
U(ICP) = Uranium Isotopes by ICP/MS
VOC = Volatile Organic Compounds

31

Table 2-5. Metals Results from May 1998 SPP Groundwater Sampling.

	Location						
Analyte	42993 (µg/L)	43993 (µg/L)	P209889 (µg/L)	B208689 (µg/L)	B210489 (µg/L)	P209489 (µg/L)	P209489 (µg/L)
Aluminum	28.7	37	13.4B	13.0B	18.6	15.0B	12.0B
Antimony	2.0U	2.0U	2.0U	2.0U	2.0U	2.0	2.0U
Arsenic	2.0U	2.0U	2.0U	2.0U	2.0U	2.0U	2.0U
Barium	124	99.2B	113	14.6B	112	77.8	76.7B
Beryllium	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U
Cadmium	0.50U	0.68	0.50U	0.50U	0.50U	0.50U	0.50U
Chromium	0.50U	0.50U	0.50U	0.50U	0.50U	0.89B	0.86B
Copper	12.1	1.0U	1.3B	2.7B	3.1	1.2B	1.1B
Iron	44.5B	20.5B	7.5U	7.5U	7.5U	29.9B	19.8B
Lead	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Lithium	648	91.7B	604	569	121	64.6B	64.8B
Manganese	294	1.6B	0.50U	141	3.4B	0.95B	0.69B
Molybdenum	27.5B	1.0U	2.1B	1.0U	1.2B	1.0U	1.0U
Nickel	87.7	4.5B	14.2B	5.9B	4.5B	7.3B	7.7B
Selenium	2.0U	2.0U	20.6	11.4	$\boxed{105}$	2.0U	2.0U
Silver	1.5U	1.5U	1.5U	1.5U	1.5U	1.5U	1.5U
Strontium	2760	1650	20700	6840	4150	644	638
Thallium	2.0U	2.0U	2.0U	2.0U	2.0U	2.0U	2.0U
Tin	1.5U	1.5U	1.5U	1.5U	1.5U	1.5U	1.5U
Vanadium	3.0B	1.1B	0.50B	1.1B	0.50U	0.50U	0.50U
Zinc	18.2B	12.0B	0.50U	13.2B	12.3B	11.5B	19.3B

B = concentration is between the instrument detection limit and the method detection limit
U = not detected at detection limit indicated
Shading indicates exceeds stream standard; box indicates exceeds Tier II groundwater action level

Table 2-6. Results of Vegetation Sampling.

Vegetation Type	Uranium-233/234 (pCi/L)	Uranium-235 (pCi/L)	Uranium-238 (pCi/L)	Total Uranium (pCi/L)
North Walnut Creek				
Tree 1 - Leaves	0.085	0.003	0.071	0.159
Tree 1 - Branch	0.007	0.000	0.001	0.008
Tree 2 - Leaves	0.055	0.001	0.059	0.115
Tree 2 - Branch	0.008	0.001	0.007	0.016
Average - Leaves	0.070	0.002	0.065	0.137
Average - Branches	0.0075	0.0005	0.004	0.012
Grasses - Sites 1,2,3	0.014	0.001	0.018	0.033
Grasses - Sites 4,5,6	0.012	0.001	0.013	0.026
Grasses - Sites 7,8,9	0.007	0.001	0.008	0.016
Average - Grasses	0.011	0.001	0.013	.025
Lindsey Ranch				
Tree 1 - Leaves	0.009	0.000	0.012	0.021
Tree 1 - Branch	0.006	0.001	0.006	0.013
Grasses - Sites 1,2,3	0.017	0.001	0.023	0.041
Grasses - Sites 4,5,6	0.019	0.001	0.020	0.040
Grasses - Sites 7,8,9	0.011	0.001	0.015	0.027
Average - Grasses	0.016	0.001	0.019	0.036

Details of the sample collection and analysis are described in *Sampling and Analysis Plan for Soils in the Area of the SPP,* RF-RMRS-97-128, RMRS, 1997d. The results of the agronomic tests and analyses were used in the phytoremediation evaluations. The data from the soil samples collected as part of site characterization for the phytoremediation system did not clearly indicate any significant chemical limitations to plant growth; however, analytical methods were not optimal for agronomic interpretations. Additionally, restrictions of effective rooting depth for some of the soils present upland of the SPP indicate the area may not ideal for implementing phytoremediation.

2.4.5 Hydrogeological Evaluations

Available RFETS and SPP-specific geologic, hydrogeologic, surface water, water quality, and meteorological data were reviewed to determine if they were adequate or sufficient for development of groundwater flow and transport models, the results of which were used in the alternative analysis (Section 3). Information regarding SEP use and waste characteristics and ITS construction and operations were also reviewed. In general, the data were found to be adequate for development of the site conceptual model and groundwater flow and transport models. For the model, assumptions and/or the values listed below were used:

- Volume of groundwater flowing under the ITS in the unconsolidated deposits and weathered bedrock was based on a water balance estimation of approximately 200,000 gallons;
- The nitrate concentration and uranium activity in groundwater in the ITS area were taken from samples collected during the 1998 field program;
- No denitrification was assumed for the plume;
- Uranium partitioning coefficient (K_d) = 1.05 L/kg (alluvium), = 0.9 – 2.5 L/kg (weathered bedrock) as derived from information presented in Honeyman and Santschi (1997) and Crawford and Stevanak (1993);
- SPP groundwater discharge to North Walnut Creek was assumed to occur along the entire length of the ITS;
- No surface water component (i.e., mixing or dilution);
- For model calibration purposes, a concentration of 6,000 mg/L nitrate was assumed for SEP water from 1954 to 1995 and 0 mg/L from 1995 to 1998.
- Groundwater on the north side of North Walnut Creek was not considered a component of the model.

2.4.6 Evaluation of Likely Sources of Uranium in SPP Groundwater

An evaluation of the source or sources of the uranium observed in the SPP groundwater (naturally occurring or the result of activities at the SEPs) was undertaken as part of the current investigations related to the SPP. This evaluation included collection of groundwater samples from wells screened in the alluvium, weathered bedrock, and competent bedrock in both background areas and the SPP area during the recent low-flow period (November 1997 through February 1998). All low-flow samples were analyzed for uranium isotopes by alpha spectroscopy (12 background wells, 5 wells in the Walnut Creek drainage outside of the SPP, and 59 wells in the SPP area). Seven SPP wells were resampled during the high-flow season (April 1998). Seven background wells and nine SPP wells (four low-flow samples and five high-flow samples) were analyzed for uranium isotopes by high-resolution inductively-coupled plasma/mass spectroscopy (ICP/MS) at Los Alamos National Laboratory (LANL).

The results of these analyses were used to calculate uranium isotope ratios, specifically, the ratio of the number of atoms (the mass) of uranium-235 (U-235) to uranium-238 (U-238), which can be used to differentiate between naturally-occurring and anthropogenic uranium. In naturally-occurring uranium, the U-235 to U-238 mass ratio is approximately 0.0072. Groundwater containing enriched uranium resulting from an anthropogenic source has a U-235 to U-238 ratio significantly above 0.0072; groundwater containing depleted uranium from an anthropogenic source has a U-235 to U-238 ratio significantly below 0.0072. Anthropogenic uranium also contains measurable quantities of U-236, a product of fission.

As a first step in analyzing the source of uranium in the SPP groundwater, the alpha spectroscopy data was converted from isotope activity to isotope mass and the U-235 to U-238 ratios calculated. The resulting ratios were very inconsistent. Samples collected from known background areas appeared to have a uranium source indicating depleted or enriched uranium. Inspection of the background data that indicated an anthropogenic source of uranium showed these samples generally contained very low uranium isotope activities. The standard alpha spectroscopy method has an error of approximately 20%. This analytical error is reflected in the calculated masses of the uranium isotopes of groundwater samples containing very low isotopic activities. This is particularly a problem with U-235, because it occurs at low activity in background groundwater, as well as in the SPP groundwater.

Because the alpha spectroscopy data was not considered to have sufficient resolution for determining uranium isotopic ratios, seven samples from background wells and nine samples from SPP wells were analyzed by ICP/MS at LANL (Figures 2-10 and 2-5). The ICP/MS method measures the mass of each isotope (U-234, U-235, U-236, and U-238) and, when detectable concentrations are encountered, has an error of 1% to 5%. This level of accuracy provides better resolution for calculating isotopic ratios. The wells selected for ICP/MS analysis represent the wide range of uranium activities found in background and SPP groundwater.

The uranium isotope masses resulting from the ICP/MS analyses are presented in Table 2-7 and the isotopic ratios calculated from these analyses are presented on Table 2-8. Figure 2-11 is a plot of U-235/ U-238 ratio versus U-236/U-238 ratio for the samples analyzed by ICP/MS. This plot clearly shows five wells and SW095 which are outside of the group near the naturally-occurring uranium line. Since U-236 is a fission product, it is only present when the source of uranium is anthropogenic. Deviations in the U-235/U-238 ratio from 0.0072, in combination with detectable quantities of U-236, present strong evidence for an anthropogenic source of uranium.

Table 2-7. Uranium Isotope Mass from ICP/MS Analyses.

Area	Sample Location	Uranium µg/liter	% Error +/-	U-234 µg/liter	% Error +/-	U-235 µg/liter	% Error +/-	U-236 µg/liter	% Error +/-	U-238 µg/liter	% Error +/-
SEP, E	P209589	414.1	3%	0.04143	8%	4.1604	3%	0.018161	11%	409.863	3%
SEP, D	P209189	13.2	3%	0.00051	13%	0.0690	3%	0.000387	9%	13.127	3%
BKGD	B405489	2.4	3%	0.00030	12%	0.0171	3%	-0.000002	597%	2.420	3%
NWC	1586	62.2	3%	0.00370	11%	0.4220	3%	0.000186	117%	61.785	3%
BKG	B302789	2.9	3%	0.00017	14%	0.0207	3%	-0.000008	127%	2.839	3%
BKG	B201589	2.1	3%	0.00012	16%	0.0149	3%	0.000000	6942%	2.062	3%
BKG	B205589	294.1	3%	0.02137	9%	2.0628	3%	-0.000407	240%	292.013	3%
BKG	B102289	0.4	3%	0.00003	29%	0.0032	4%	-0.000005	31%	0.445	3%
BKG	B305389	8.7	3%	0.00056	8%	0.0618	3%	0.000002	1458%	8.590	3%
BKG	B203189	3.9	3%	0.00037	12%	0.0276	3%	-0.000006	238%	3.888	3%
SEP, D	43993	100.4	3%	0.00583	7%	0.6312	3%	0.002908	10%	99.793	3%
SEP, E	42993	2987.7	3%	0.24241	8%	26.9832	3%	0.187029	7%	2960.249	3%
NWC	B208689	150.9	3%	0.01098	9%	1.0607	3%	-0.000190	264%	149.858	3%
SEP	P209889	102.3	3%	0.00784	9%	0.7336	3%	0.000117	299%	101.553	3%
NWC	B210489	55.1	3%	0.00357	13%	0.3901	3%	0.000022	923%	54.685	3%
SEP, D	P209489	43.4	3%	0.00250	10%	0.2779	3%	0.002188	6%	43.087	3%

Table 2-8. Calculated Uranium Isotope Ratios from ICP/MS Data.

Area	Sample Location	U-234/U-238 Ratio	% Error +/-	U-235/U-238 Ratio	% Error +/-	U-236/U-238 Ratio	% Error +/-
ITPH	SW095	7.81E-05	26%	8.328E-03	5%	2.41E-05	27%
SEP	46393	7.21E-05	17%	7.329E-03	5%	Not Calculable	7%
SEP, E	P209589	1.03E-04	9%	1.03E-02	4%	4.47E-05	11%
SEP, D	P209189	3.95E-05	13%	5.33E-03	4%	2.98E-05	9%
BKG	B405489	1.28E-04	13%	7.17E-03	4%	Not Calculable	598%
NWC	1586	6.10E-05	11%	6.92E-03	4%	Not Calculable	36%
BKG	B302789	6.22E-05	14%	7.38E-03	4%	Not Calculable	127%
BKG	B201589	6.09E-05	16%	7.33E-03	4%	Not Calculable	6942%
BKG	B205589	7.44E-05	9%	7.15E-03	4%	Not Calculable	240%
BKG	B102289	7.78E-05	29%	7.36E-03	5%	Not Calculable	31%
BKG	B305389	6.61E-05	9%	7.29E-03	4%	2.47E-07	1458%
BKG	B203189	9.63E-05	12%	7.19E-03	4%	Not Calculable	238%
SEP, D	43993	5.94E-05	8%	6.41E-03	4%	2.94E-05	11%
SEP, E	42993	8.33E-05	8%	9.23E-03	4%	6.37E-05	8%
NWC	B208689	7.46E-05	10%	7.17E-03	4%	Not Calculable	264%
SEP	P209889	7.85E-05	10%	7.32E-03	4%	1.16E-06	299%
NWC	B210489	6.65E-05	13%	7.22E-03	4%	3.99E-07	923%
SEP, D	P209489	5.91E-05	11%	6.53E-03	5%	5.12E-05	7%

E = enriched
D = depleted
All others = natural

ITPH = Interceptor Trench Pump House
SEP = Solar Evaporation Pond Area
BKG = Background Location
NWC = North Walnut Creek drainage
Not Calculable = Ratio < 0 because of negative analytical result

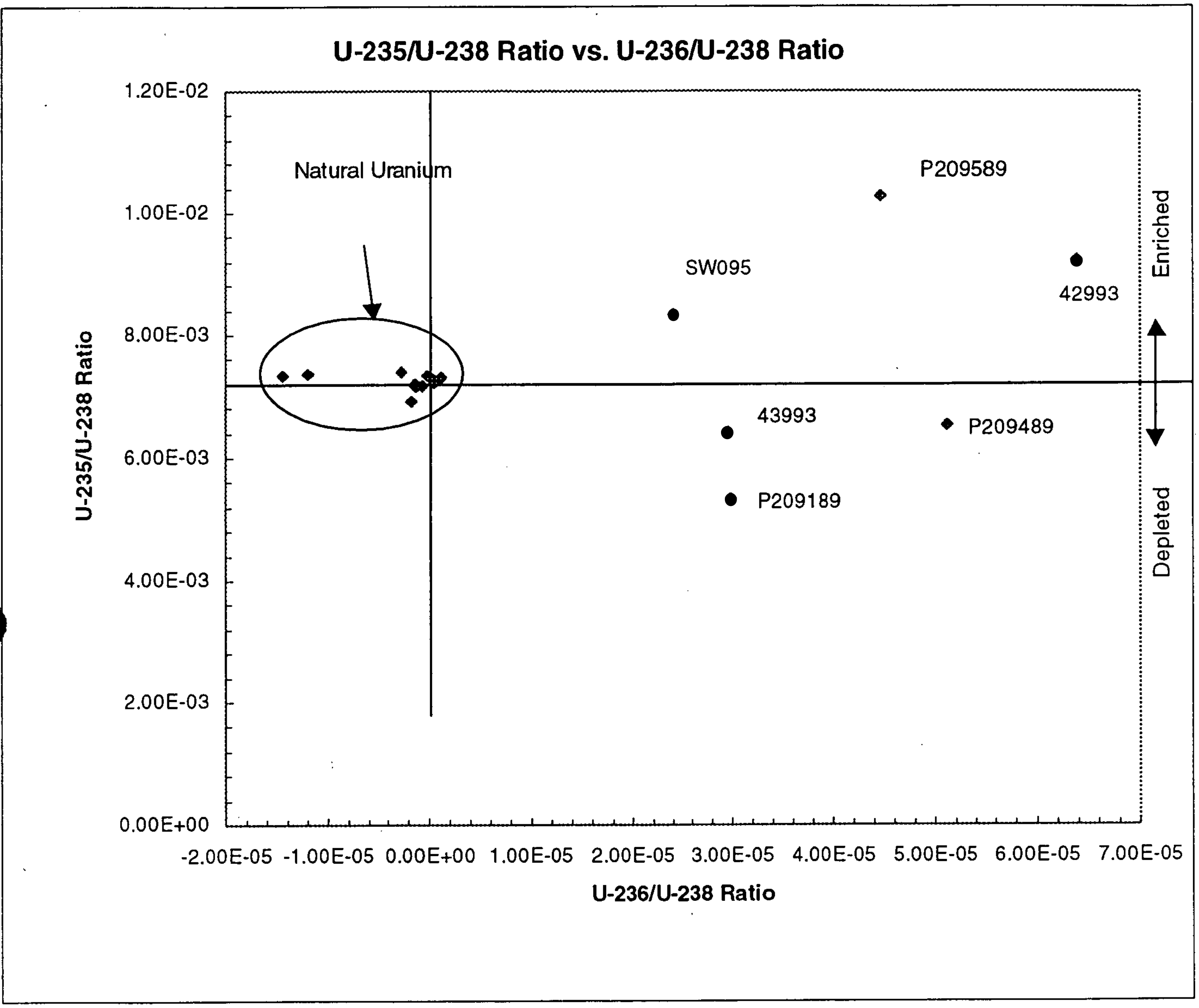
All five well samples were collected within 100 feet of the Solar Evaporation Ponds; three of these samples indicate depleted uranium is present (increased U-238) and two samples indicate enriched uranium is present (increased U-235). There is no correlation between the total activity of uranium in the samples and the source of uranium. The five well samples that indicated an anthropogenic source of uranium had activities between 6.497 and 1605.5 pCi/L, while the four samples that indicated a natural source of uranium had activities between 42.274 and 72.72 pCi/L.

The sample collected at SW095 also indicates the presence of uranium 236 and depleted uranium. While this location is outside of the anthropogenic uranium plume, these sample results indicate that the ITS system is collecting groundwater contaminated with anthropogenic uranium from the source area.

The U-235/U-238 ratios presented in this table, in combination with a lack of U-236, indicate that the uranium in all background samples is naturally occurring. Four wells in the SPP area also have U-235/U-238 ratios that indicate the uranium is naturally occurring. Three of the four SPP samples indicating a natural source of uranium occurred in the valley fill alluvium or weathered bedrock adjacent to North Walnut Creek. The fourth sample was collected from the weathered bedrock adjacent to the southern ITS trench approximately 200 feet to the north of SEP 207-B North. These data indicate that groundwater containing anthropogenic uranium has not yet reached the groundwater adjacent to North Walnut Creek drainage.

The total uranium activities resulting from the alpha spectroscopy analyses of the low-flow sampling event, as well as the uranium source determined by ICP/MS, for the background wells and SPP wells are shown on Figures 2-10 and 2-5, respectively. The values in the area where the uranium source was determined to be anthropogenic are contoured. This map indicates that the uranium plume has not yet reached the groundwater adjacent to North Walnut Creek. No wells within the ITS drain area contained sufficient water to collect a sample for uranium analysis during either sampling event.

Figure 2-11. U-235/U-238 Ratio vs. U-236/U-238 Ratio.



3.0 ALTERNATIVES EVALUATION/ ALTERNATIVES ANALYSIS

As discussed in RMRS (1997a), originally eleven alternatives were evaluated and screened against a set of criteria. As a result of this screening, the technologies retained for further analysis were no action, phytoremediation, treatment at Building 995, managed release, and enhanced evaporation (RMRS, 1997a). A re-analysis of alternatives was performed to incorporate:

- Changes in selection criteria
- A technical evaluation of phytoremediation
- A treatability study on the Building 995 operation
- Recent technical information on zero-valence iron

The re-analysis included the following alternatives:

- No Action (Direct Release)
- Managed Release
- Treatment at Building 995
- Reactive Barrier
- Phytoremediation
- Evaporation at Building 374
- Treatment at MSTs
- Constructed Wetlands
- Off-Channel Evaporation Pond
- Enhanced Evaporation
- Dispersion Field (Leach Field)

Additionally, some of the alternatives were evaluated using groundwater flow and transport models to assess long-term effectiveness. The model descriptions are summarized in Section 3.2.

3.1 Alternative Description

As a result of the re-analysis of alternatives, the following alternatives are evaluated further in Appendix A and summarized in this section: no action, managed release, treatment at Building 995, phytoremediation, and reactive barrier. Each alternative was evaluated with regard to its ability to meet the long-term goals for the SPP and RFETS which are to:

- Ensure compliance with stream standards for nitrate and uranium

- Provide a long-term, passive solution to the movement of contaminated groundwater from the SEP area to North Walnut Creek

- Support goals of the RFCA and the Site Closure Plan which calls for site closure within 10 years

- Significantly reduce SPP water management and treatment costs

- Meet the fiscal year 1999 milestone for initiating remediation of the SPP

3.1.1 No Action

The no-action alternative is defined as no additional action as well as a cessation of previous interim remedial actions. Specifically, the ITS, MSTs, Interceptor Ditch Pump House, and associated fixtures and pipelines would be deactivated and decommissioned. This alternative is identical to the Direct Release Alternative in the *SPP Remediation and ITS Water Treatment Study* (RMRS, 1997a). Surface water and groundwater would flow into North Walnut Creek through natural conveyances. Because the ITS system would be grouted as part of deactivation, it would remain a partial impediment to groundwater flow and plume migration; however, once steady-state conditions are met, the effectiveness of the ITS as a barrier will likely be negligible. Prior to implementing grouting of the ITS, the impacts would be analyzed to ensure that it does not force the groundwater plume into previously uncontaminated areas.

3.1.2 Managed Release of ITS Water

Implementability of the managed release alternative assumes the interim nitrate surface water standard of 100 mg/L is accepted. Phase I of the alternative includes ceasing transfer of water from the ITS pump house to the MSTs allowing overflow from the pump house to North Walnut Creek. The ITS would be decommissioned by grouting after capping of the Solar Ponds in 2005. Technical evaluation of the impacts of the first phase on North Walnut Creek indicates that the nitrate and uranium surface water standards would be met, except for infrequent seasonal exceedances (RMRS, 1997a); however, the 100 mg/L interim nitrate standard is only a temporary modification effective until 2009. For the Long-Term Site Condition, the 10 mg/L nitrate standard must be met.

3.1.3 ITS Water Treatment at Building 995

This remedial alternative would involve continued collection of the SPP by the ITS, storage at the MSTs or other tanks or ponds, and treatment at Building 995 (the current wastewater treatment plant) rather than at Building 374. Computer modeling was conducted to evaluate if the nitrate concentrations in the ITS water could be adequately treated by the Building 995 treatment system. The model results indicated that the existing facilities at Building 995 could adequately handle the ITS water. The model also estimated the amount of additional uranium which would accumulate in the biosolids of Building 995 as a result of treating the ITS water. The model results indicated that the uranium in the biosolids would be within the acceptable range for land disposal.

Building 995 can accept 4 gallons per minute (gpm) of flow from the ITS, which accommodates the ITS flow with the exception of the high flow season (i.e., spring runoff). During spring runoff, the flow to the ITS would exceed 4 gpm. As a result, storage of the excess water would be required.

Treatment at Building 995 costs less than treatment at Building 374 (approximately $.30 per gallon and $2.00 per gallon, respectively); therefore, it would provide a cost-effective interim alternative for treatment of ITS water. The primary drawback to selecting this alternative as a long-term remedy is that it is neither permanent nor passive. Treatment at Building 995 requires continued use of the MSTs; this involves personnel to manage the transfer of water from the ITS to the MSTs and from the MSTs to Building 995. In addition, Building 995 is scheduled for decommissioning in 2006 and treatment of the SPP is expected to be required beyond 2006 to ensure compliance with stream standards.

3.1.4 Phytoremediation

Phytoremediation is a natural process whereby contaminants in the subsurface are accumulated, converted to biomass, or otherwise immobilized via plant uptake. Phytoremediation incorporates agronomic techniques to ready the contaminated soil or soil overlying contaminated groundwater for planting and to ameliorate chemical and physical limitations to plant growth. The goal of phytoremediation is to either remove the pollutant from the contaminated matrix or to alter the chemical or physical nature of the contaminant within the subsurface so that it no longer presents a risk to human health or the environment.

Two phytoremediation system designs were evaluated to assess the potential effectiveness of phytoremediation in removing nitrate from groundwater in the SPP. These were a passive system and a combined passive/active system. The design of both systems was based on the assumption that the uranium resulting from operations at the SEPs would be removed prior to the water entering the ITS. The passive system would involve planting native phyreatophytic (plants which extend roots to the water table) vegetation within the present SPP footprint. Vegetation in the passive system would not require irrigation once established because the groundwater within the footprint is shallow enough to allow the uptake required for growth. In the process, the plants would use nitrate as a nutrient and allow accumulation of organic nitrogen in the soil. However, the passive system is considered limited because it can not be used to treat areas of the SPP where the water table is too deep to allow direct uptake by the vegetation.

The passive/active system included the passive system as described above, as well as an active component placed outside of the SPP footprint to allow for treatment of the SPP in its entirety. Water collected by the ITS would be used to irrigate the vegetation in the active component, thus removing the majority of the nitrate from the SPP groundwater. Limitations of the passive/active system include 1) the use contaminated plume water for irrigation outside the existing plume area thus providing a potential avenue for additional groundwater contamination and 2) the long-term operation and maintenance of an irrigation system.

In 1998, Preble's Meadow Jumping Mouse *(Zapus hudsonius preblei)* was listed on the Threatened Species List (50 CFR Part 17, May 13, 1998). One area of prime habitat extends along the North Walnut Creek drainage in a swath 100 yards wide on either side of the centerline of the creek. Given this orientation the habitat may extend into the ITS area. It was recognized in the Draft Conceptual Design Report that implementation of the phytoremediation alternative could possibly benefit the Preble's Jumping Mouse habitat by the creation of dense vegetation in the area; however, because the U.S. Fish and Wildlife Service (USFWS) must approve any actions that would disturb the habitat of a threatened species, impediments to implementability may be encountered.

3.1.5 Reactive Barrier

The reactive barrier consists of a funnel system to direct groundwater flow to a treatment cell containing zero-valence iron and a carbon source such as peat or saw dust. The nitrates would be chemically reduced and uranium would immobilize in the treatment cell through absorption and/or reduction by the iron. Multiple treatment cells will be utilized to better distribute the flow and to divert water away from areas with a high potential for slumping. Use of treatment cells will allow simpler maintenance since the treatment media will be consolidated in the cells instead of along the entire barrier. A treatability study is in progress to determine more specific design specifications such as the volume of the zero-valence iron and the effect of a carbon source on denitrification. Because the reactive barrier is a passive system, it would not significantly alter the overall hydraulic conductivity.

The collection trench will be approximately 850 feet long (which is the required width to capture the Tier II nitrate plume), two to three feet wide, and approximately 20-30 feet deep. The width of the trench would be dictated by design considerations. It is anticipated that the trench would extend about ten feet into the weathered bedrock to capture both bedrock and alluvial flow. An impermeable barrier would be placed on the downgradient side so that flow is effectively diverted to the treatment cells. The collection trench would be filled with a highly permeable media such as gravel to enhance flow in the perforated PVC pipe and subsequently to the treatment cells. A geotextile would be placed at the top of this media to prevent backfilled soils from settling into the reactive barrier. The Fish and Wildlife Service has been consulted and has concurred with the assumption that implementation of the proposed alternative will not adversely affect the Preble's Meadow Jumping Mouse.

3.2 Groundwater Flow and Transport Model to Evaluate Remedial Alternatives

Several groundwater-modeling tools were used to evaluate the retained remedial alternatives. These tools included the following:

- ***Plume flushing model:*** Developed to provide a preliminary estimate of plume cleanup time.

- ***Two-dimensional plan-view plume model:*** Developed to provide estimates of plume migration rates, assist in evaluating parameter values, and provide preliminary sensitivity analyses for key transport parameters.

- ***Two-dimensional numerical vertical plane flow and transport models:*** Developed for evaluation of three remedial alternatives (not phytoremediation).

Specifically, the numerical flow and transport models used were MODFLOW-SURFACT (HydroGeoLogic, 1996) and MODPATH (U.S. Geological Survey [USGS], 1994). MODFLOW-SURFACT is a three-dimensional numerical finite-difference model based on MODFLOW (USGS). MODFLOW-SURFACT was used to analyze groundwater flow within a two-dimensional vertical cross-section of the aquifer that extended along the axis of the SPP from the SEPs to North Walnut Creek. MODPATH (USGS, 1994) was used to calculate the flow path of particles within the groundwater flow field using the output from MODFLOW-SURFACT.

The alternatives evaluated by the models included no action, managed release, and treatment at Building 995. Effects of the phytoremediation alternative were not simulated based on discussions among the project team prior to conducting the modeling. Additionally, simulations did not specifically address the reactive barrier technology because the alternative was incorporated into the alternative analysis after the modeling had been performed. For the alternatives considered, the models were used to estimate:

- Water levels, hydraulic gradients, and groundwater flow rates within the UHSU;
- Dissolved chemical transport (plume migration rates);
- Groundwater fluxes in the unconsolidated deposits and weathered bedrock aquifer zones;
- Changes in water budget for each aquifer zone caused by SEP capping;

- Chemical concentrations in each aquifer zone;
- Fluxes of both groundwater and dissolved mass to North Walnut Creek.

For model purposes, the SPP groundwater flow system was conceptualized as a shallow hillside aquifer consisting of an upper layer of unconsolidated deposits underlain by a zone of weathered claystone bedrock. The unconsolidated deposits and the weathered bedrock together are referred to as the UHSU. The weathered bedrock zone grades into relatively impermeable competent claystone bedrock that forms the base of the flow system. Groundwater enters the SPP area as underflow from the IA of RFETS. Recharge to the aquifer comprises leakage through the SEPs and infiltration of precipitation on the hillside. Under natural conditions, groundwater discharges to the North Walnut Creek drainage at the base of the hill slope.

Currently, the majority of the groundwater flowing in the unconsolidated deposits of the hillside aquifer are collected by the ITS. Figure 3-1 shows a conceptual diagram of SPP groundwater flow system and model boundary conditions. Figure 3-2 shows the location of the model cross-section.

The UHSU was modeled as two hydrostratigraphic units: an upper unconsolidated layer varying in thickness from approximately 5 to 20 feet; and an underlying weathered claystone layer varying in thickness from approximately 20 to 60 feet. The competent claystone beneath the weathered zone was considered the impermeable base of the flow system. The model consisted of 10 layers and 353 columns; layers 1 and 2 represented the unconsolidated deposits and layers 3 through 10 represented the weathered bedrock. The parameter values used in setting up the cross-section model were based on the results of previous investigations of the SPP and RFETS in general. The french drains which comprise the ITS were represented in the model as drain cells which extended to the base of the unconsolidated deposits and captured all of the flow in the alluvium in these areas.

Beginning with the 1998 plume conditions estimated from the low-flow event sampling data, model simulations were conducted to evaluate the remedial alternatives of no action, managed release, and treatment at Building 995. Modeling the continued use of the ITS or use of an enhanced ITS (french drains deepened into the weathered bedrock) corresponds to the effects of implementing the managed release or treatment at Building 995 remedial alternatives. Modeling of discontinued use of the ITS corresponds to the no action (i.e., baseline) condition. For all of these simulations, it was assumed that an impermeable cap was placed over the SEPs in 2005 and any surface run-off from the capped area was collected and diverted. The simulations evaluated the conditions for a period of approximately 100 years. Nitrate concentration versus time in the UHSU under the scenarios modeled indicated that the groundwater adjacent to North Walnut Creek would continue to exceed 100 mg/L beyond the modeled period (year 2100).

Nitrate mass flux to North Walnut Creek was also simulated for continued use of the ITS (i.e., managed release or treatment at Building 995) and closure of the ITS (i.e., no action). The results of the simulations support the following conclusions:

- The existing ITS significantly reduces the rate of nitrate mass flux to North Walnut Creek by reducing flow through the unconsolidated deposits.

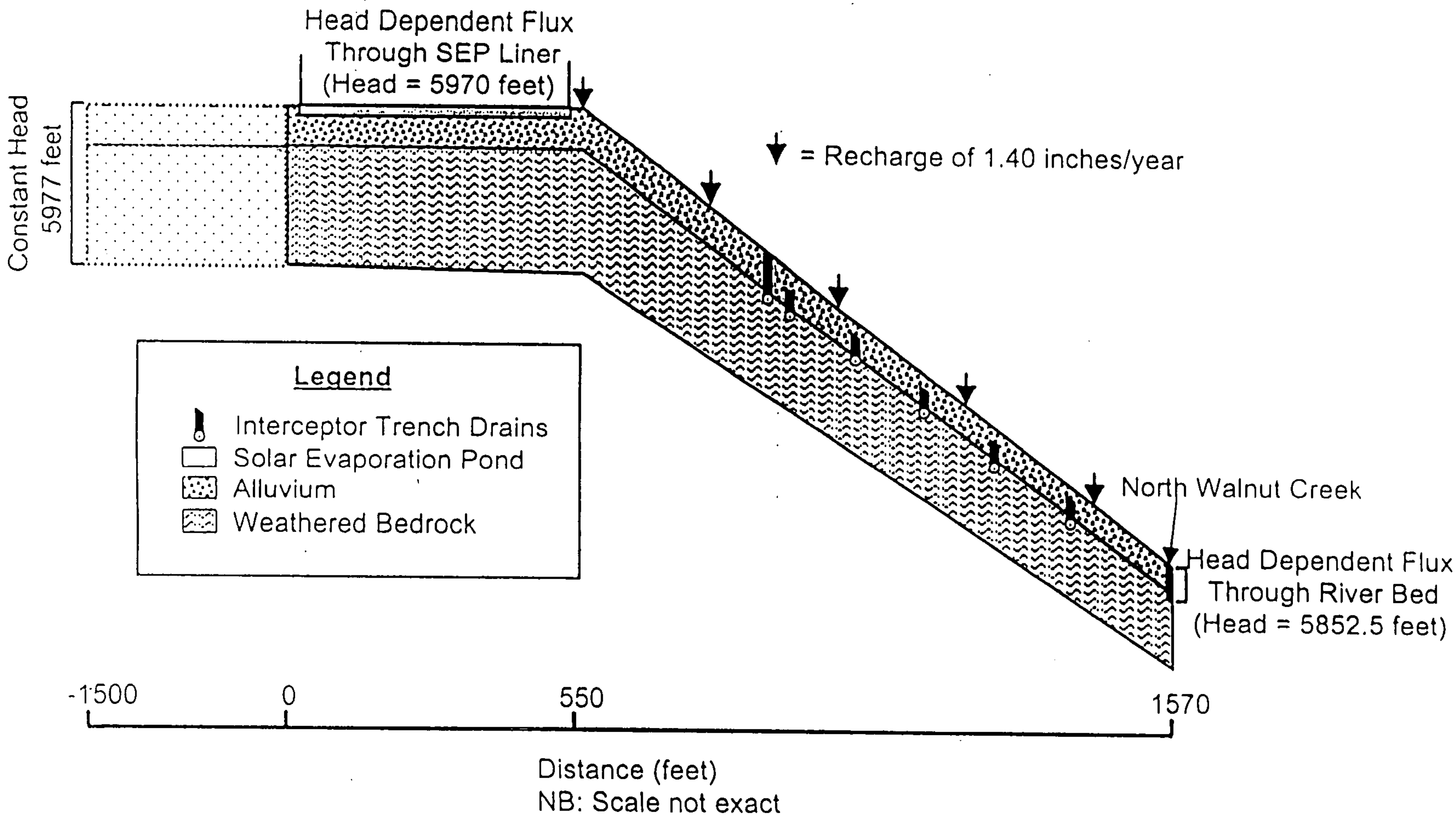


Figure 3-1: Conceptual diagram of SPP groundwater flow system and model boundary conditions.

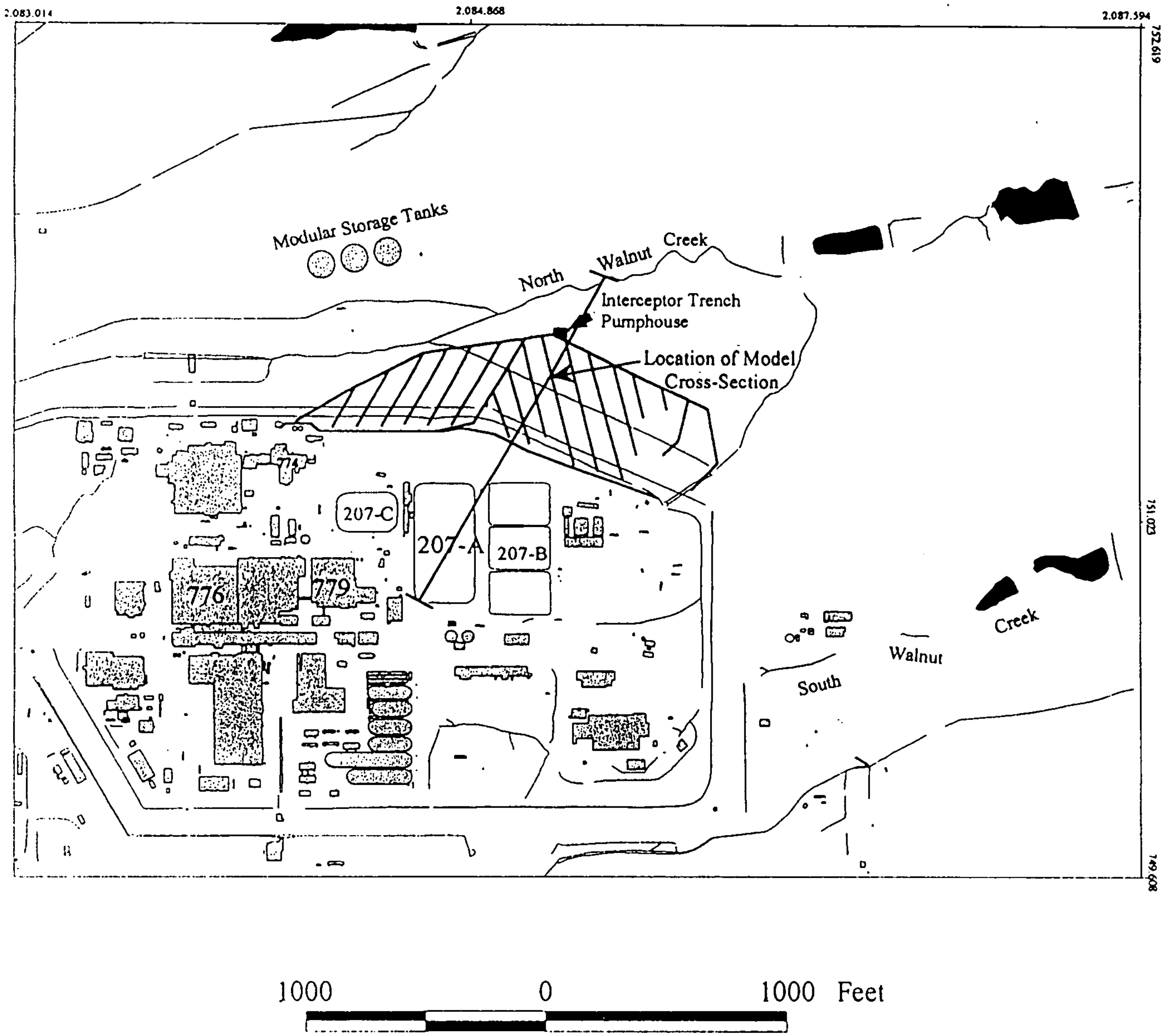


Figure 3-2

Location of Model Cross-Section

Rocky Flats Environmental Technology Site

Explanation

- Streams
- Interceptor Trench System (ITS)
- Solar Ponds
- Buildings
- Lakes

N

44

- Nitrate mass flux is higher in the unconsolidated deposits than in the weathered bedrock.
- Approximately 90% of the total nitrate mass flux in the weathered bedrock is in the upper half of the unit.

The results from the groundwater fate and transport model indicate treatment for removal of nitrate will be required in order to meet the long-term goals for protection of North Walnut Creek.

3.3 Alternatives Analysis

Appendix A details the results of the alternative analysis. The five alternatives subject to a more comprehensive alternative analysis were:

- No Action (Direct Release),
- Managed Release,
- Treatment at Building 995,
- Reactive Barrier, and
- Phytoremediation.

Each alternative was evaluated with respect to effectiveness, implementability, and cost. National Environmental Policy Act (NEPA) values also played an important role in alternative selection. In particular, emphasis was placed on preserving the habitat of the Preble's Meadow Jumping Mouse, a threatened species under the Endangered Species Act. Emphasis was also placed on long-term passive remediation methods. Additionally, the alternatives were evaluated based on their ability to remove both nitrates and uranium. The decision process ultimately was used to determine which alternative was feasible and offered the greatest degree of protectiveness to the public, workers, and the environment including Preble's Meadow Jumping Mouse habitat.

Reactive barrier was selected as the preferred alternative because the other alternatives were found to be ineffective in treating the contaminants (Alternatives 1 and 3) or did not achieve the long-term goals for the SPP and RFETS (Alternative 2). With respect to Alternative 4, there is not sufficient space available for either of the phytoremediation approaches. The passive system as designed would require about 18 acres, but only about one-third of the nitrate loading could be addressed. The passive/active system would require 61 acres which is greater than the plume extent, and the construction of additional phytoremediation areas elsewhere would result in the spread of contamination to previously uncontaminated areas.

Reactive barrier has moderate capital costs; however, it would provide the greatest level of groundwater treatment of all the alternatives. It is the recommended alternative for the following reasons:

- Nitrates would be reduced;
- It offers the greatest degree of protectiveness;
- It would have very minimal impacts to Preble's Meadow Jumping Mouse habitat;
- Most of the disruption during installation will occur outside the habitat area;
- It is a long-term solution;
- It does not require elements of the RFETS infrastructure that are likely to be abandoned;
- The technology is available and has become more established;

- Groundwater flow can be restored to its natural discharge point in the drainage system (i.e., under natural conditions, groundwater discharges to the North Walnut Creek drainage at the base of the hill slope);
- It offers the greatest degree of flexibility;
- The reactive barrier is passive and low maintenance;
- Uranium would be removed; selenium and other metals which occur in some SPP groundwater monitoring wells would also be treated.

Table 3-1 summarizes the overall comparison of alternatives.

Table 3-1. Overall Comparison of Alternatives[1]

Criteria	ALTERNATIVES				
	Alternative 1- No Action	Alternative 2 – Managed Release	Alternative 3 - Treatment at Building 995	Alternative 4 – Phytoremediation	Alternative 5 - Reactive Barrier
Effectiveness	**Not Effective –** Nitrate concentrations would increase and exceed ARARs for North Walnut Creek	**Moderate –** Provides good short-term protection since water would be analyzed prior to release.	**Not Effective** - STP cannot handle high loading due to precipitation events. Uranium is not addressed if biosolids are to be land farmed. This is not a long-term alternative because the STP will be closed down.	**Low** - Could only address one third of the current ITS liquid waste stream.	**Good-** uranium is treated and water is denitrified to ensure applicable surface water standards are met.
Implementability	**High –** This alternative would require little effort other than closure of the ITS.	**Low –** The technology is readily available. Implementation would consist of installing additional lines and decommissioning the ITS. Highly dependent on surface water ARARs and a point of compliance downstream of A-4 Pond.	**Low -** This would be very implementable as long as biosolids continued to be sent to Nevada Test Site; however, it is dependent on continued operation of the STP.	**Low –** Impediments to implementability construction in Preble's Mouse habitat must be approved by USFWS	**Moderate -** Reactive barriers have become a more prevalent technology. It is possible to implement with minimal impact to Preble's Mouse habitat.
Cost	**Cost=$207,000** **Low Cost-** The cost is low because no treatment would be implemented to address the plume.	**Cost-$748,000** **Moderate Cost-** Cost-effective due to both low capital and annual costs	**Cost = $17,233,800** **High Cost-** High annual costs made this the most costly alternative	**Cost = $1,046,000** **Moderate Cost –** Annual costs are relatively low	**Cost = $1,752,000** **Moderate Cost-** This alternative had the highest capital costs but low annual cost.

[1]Consistent with the Implementation Guidance Document, the purpose of the overall comparison is to rank, on a semi-quantitative basis (i.e., low, moderate, high), so that a recommended alternative may be selected.

47

4.0 PROJECT OBJECTIVES

The funnel and gate system will extend horizontally along the north side of the North Access Road through the highest nitrate portion of the SPP and extend vertically approximately 10 feet into the weathered bedrock. The majority of the system will be a barrier that will funnel water to the gate, which will contain the reactive media.

The objectives of the SPP remediation include the following:

- Protect North Walnut Creek by reducing the mass loading of nitrate to surface water and ensure that surface water standards are met in the Creek.
- Design and install a passive system to intercept and treat the contaminated groundwater of the SPP to remove nitrate.
- Design and construct the reactive barrier system in a manner which minimizes the generation of low-level mixed waste and/or hazardous waste and protects the habitat of Preble's Meadow Jumping Mouse, which was added to the Threatened Species List on May 18, 1998.
- Design the reactive barrier system to allow easy access for operations and maintenance and reactive media replacement or removal.
- Evaluate effectiveness of reactive barrier system in removing nitrate.
- Evaluate long-term effectiveness of the treatment system once it has been in operation for several years.

48

5.0 PROPOSED APPROACH

The proposed approach to the SPP remediation is to install a reactive barrier north of the Solar Ponds on the northern side of the North Access Road and to utilize treatment cells containing zero-valence iron and organic media placed at the west end of the barrier. Figure 5-1 shows the location of the reactive barrier. Treatability testing will be required prior to design. The ITS system upstream of the barrier will be left in place to enhance the recovery of groundwater. Construction of the system is currently scheduled to begin in June 1999 and be completed in August 1999. The ITS system will be cut during installation of the reactive barrier (Section 5.2) and the resulting water will be managed (Section 5.3). Seepage collected during construction activities will be directed to the MSTs, commencing with the mobilization for installation of the barrier. The construction dewatering is anticipated to last less than six months and will cease upon completion of the installation, at which time the new system will begin treatment.

Because of the similarities in the SPP and the Mound Plume Project, the lessons learned will be incorporated into the project by design and executed during construction. The major lessons learned from the Mound Plume Project include:

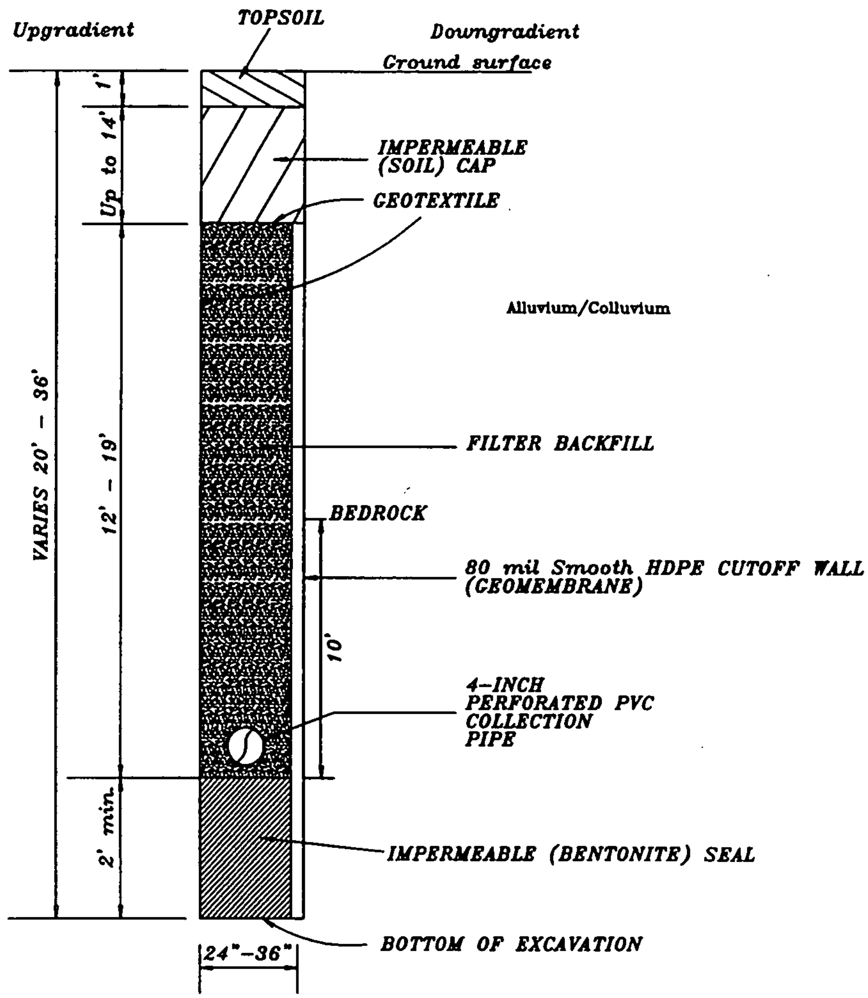
- Safe work practices resulted in identification of hazards prior to these becoming problems.
- Excavations should remain open for as brief a period as possible.
- Equipment and materials utilized must be efficient and effective for the task (i.e., valves and piping).
- Backfill operations must be conducted in a manner that protects equipment and materials remaining within the excavation.

5.1 Reactive Barrier Design

Modeling results presented earlier indicated that the largest reduction in nitrate flux to North Walnut Creek could be achieved by enhancing or deepening the collection trench closest to North Walnut Creek so that it captured the flow in the weathered bedrock. Due to constructibility considerations, Preble's Mouse habitat issues, cost considerations and other drawbacks, enhancing the ITS is not feasible or practical. However, a collection trench that is installed down into the weathered bedrock will collect the same groundwater with a lower cost and impact to the environment. The construction would be restricted to the disturbed area around the North Access Road. Equipment could be staged to the east and south, outside of Preble's Mouse habitat.

Two treatment cells will be used. The first cell will be filled with a mixture of organic media (sawdust) to act as a carbon source to induce denitrification and zero-valence iron to remove the uranium by chemical reduction. Nutrient mulch, which will increase the denitrification rate, can also be added to the iron/sawdust treatment media. The second cell will be filled with 100 percent granular activated iron aggregate. The two treatment cells will be utilized to better distribute the flow and to divert water away from areas with a high potential for slumping. Use of treatment cells will allow simpler maintenance since the treatment media will be consolidated in the cells instead of along the entire barrier. Figure 5-2 shows a plan view of the conceptual design of the collection trench.

The collection trench will be approximately 850 feet long, two to three feet wide, and approximately 20-30 feet deep. The width of the trench will be dictated by design considerations. It is anticipated that the trench will extend about ten feet into the weathered bedrock to capture both bedrock and alluvial flow. An impermeable barrier will be placed on the downgradient side so that flow is effectively diverted to the treatment cells. The collection trench will be filled with a highly permeable media such as sand to



TYPICAL TRENCH CROSS SECTION

NOT TO SCALE

Figure 5-2
Collection Trench Details

enhance flow to the perforated PVC pipe and subsequently to the treatment cells. Geotextile will be placed at the top of this media to prevent backfilled soils from settling into the reactive barrier. Figure 5-2 shows a conceptual cross-section of the recommended design of the portions of the collection trench in between treatment cells.

5.2 Interceptor Trench System

The collection trench will intercept the ITS allowing groundwater collected by the ITS upgradient from the reactive barrier to flow into the new collection trench. The ITS lines which are not intercepted by the barrier wall will be sealed off at the upgradient end with impermeable material. This will permit the ITS to be used to enhance recovery upgradient but not to short circuit the treatment cells at the collection trench.

At present, the ITS system is also collecting surface water in the southern most trench. The gravel in this ITS trench extends to ground surface to allow surface water collection along with groundwater collection. Approximately 700,000 gallon of water flow into this trench each year. As part of this remedial action the trench will be paved or grouted to prevent run-off from flowing into the ITS and the reactive barrier.

5.3 Construction Water Management

Dewatering the construction site is essential for the safety of personnel and to facilitate timely construction. Alternatives considered for handling seepage during trench construction were:

1) discharge directly to Pond A-1, A-2 or A-3,
2) discharge directly to Pond B-1 or B-2,
3) transfer to the Sewage Treatment Plant (STP) for treatment,
4) transfer to the existing MSTs for storage, followed by treatment or discharge,
5) transfer to Building 891 treatment system for treatment,
6) transfer to Building 374 for treatment, and
7) transfer to the Solar Ponds Plume Treatment System after construction is completed for treatment.

The approach for handling the construction water will utilize the existing and accepted water management system (i.e., MSTs). The construction water will be stored in the MSTs then either routed for treatment at Building 374, piped into the new Solar Ponds Plume treatment system, or discharged to the B-Series Ponds. In the unlikely event of an emergency situation, there is a possibility that water will be discharged directly to Pond A-1 or A-2. Any discharge to these ponds is expected to be short-term during emergency situations only.

Construction of the barrier will intercept some of the existing transfer lines. When intercepted, these lines will be reestablished sufficiently so that the trench can continue to be dewatered and the construction water transferred to the MSTs.

5.4 Worker Health and Safety

A Site-Specific Health and Safety Plan (HASP) will be developed to address the safety and health hazards of each phase of project operations and to specify the requirements and procedures for employee protection. The Occupational Safety and Health Administration construction standard for Hazardous Waste Operations and Emergency Response, 29 Code of Federal Regulations (CFR) 1926.65 will be used as the basis for the HASP. In addition, DOE Order 5480.9A, Construction Project Safety and Health Management, applies to this project. This order requires preparation of Activity Hazard Analyses (AHAs)

52

to identify each task, hazards associated with each task, and controls necessary to eliminate or mitigate the hazards. The AHAs will be included in the HASP.

This project could potentially expose workers to physical, chemical, and low levels of radiological hazards. The physical hazards include those associated with excavation activities, use of heavy equipment, noise, heat stress, cold stress, and work on uneven surfaces. Physical hazards will be mitigated by appropriate use of personal protective equipment (PPE), engineering, and administrative controls. Because chemical, skin, and respiratory hazards are not anticipated due to extremely low concentrations and nature of contaminants, the use of PPE is not anticipated. If monitoring indicates the need for PPE and a hazard exists, the hazards will be mitigated by the use of PPE and administrative controls. Routine VOC monitoring will be conducted with an organic vapor monitor for any employees who must work near the contaminated soil (i.e., soil sampling or excavation personnel). Based on employee exposure evaluations, the Site Health and Safety Officer may downgrade personal protective equipment requirements, if appropriate.

Since this is not a radiological area, continuous radiological controls are not expected to be required. However, the HASP will include project "hold points," which will account for unanticipated hazards such as contaminated debris. Radiation monitoring will be included as appropriate to meet this approach in the HASP per the RFETS Radiological Controls Manual (Kaiser-Hill, 1996).

If field conditions vary from the planned approach, an AHA will be prepared for the new conditions, and work will proceed according to the appropriate control measures. Data and controls will be continually evaluated. Field radiological screening will be conducted using radiological instruments appropriate to detect surface contamination and airborne radioactivity. As required by 10 CFR 835, Radiation Protection of Occupational Workers, applicable RFETS implementing procedures will be followed to insure protection of the workers, co-located workers, the public, and the environment. The HASP will describe the air monitoring equipment and methods to be used to monitor for VOCs, particulates, and radiation. Finally, dust minimization techniques will be used to minimize suspension of contaminated soils.

5.5 Performance Monitoring

Performance monitoring will be conducted to determine the effectiveness of the system in meeting the project objectives. Monitoring of the treatment system will be accomplished by comparing results of the treatment system influent and effluent. Additionally, surface water quality will be monitored at a point of evaluation in North Walnut Creek at a location downgradient of the SPP. The current stream standard for nitrate, 100 mg/L, is a temporary modification to the 10 mg/L water quality standard. The current stream standard is effective through 2009. After expiration of the temporary modification, the stream standard is expected to decrease to 10 mg/L.

Preliminary decision rules for the project are presented below. The performance monitoring data will initially be used to evaluate and optimize the treatment system efficiency and effectiveness. As goals for post-closure conditions are established, the performance monitoring data will be used to further refine the decision rules for the treated effluent. Decision rules for this monitoring will be defined and evaluated as a special project within the Integrated Monitoring Program (IMP) and refined as necessary in the final Site Corrective Action Decision/Record of Decision (CAD/ROD).

The schedule for monitoring is shown in Table 5-1. After sufficient data are gathered to demonstrate stable conditions have been achieved, the requirements may be changed to annual or less frequent monitoring.

Table 5-1. Schedule for Water Quality Sampling and Water Level Measurements.

Task	Month 1-6	Months 7-12	Subsequent Years
Treatment System Influent	Monthly	Quarterly	Semi-Annually
Treatment System Effluent	Monthly	Quarterly	Semi-Annually
Downgradient Surface Water Quality	Monthly	Quarterly	Semi-Annually
Hydraulic Head in Collection Trench	Monthly	Quarterly	Semi-Annually

Influent concentrations will be measured at the piezometer nearest to the collection cell. Effluent concentrations will be measured at the metering manhole to determine treatment efficiencies. The influent will be sampled at the same frequency as the effluent. Physical problems, not treatment limitations, are expected to determine when the treatment media will require replacement. It is expected that the organic treatment media will provide a carbon source in excess of what would be needed for nitrate reduction and therefore would not require replacement. However, the organic media may plug due to bacterial growth blocking the pore spaces. To detect such a condition, piezometers will be installed near the treatment cell to monitor water levels. Steadily increasing water levels may be an indication that the media is plugged, requiring replacement. Replacement will be accomplished by digging up the spent treatment media and replacing it with new.

If effluent concentrations exceed system performance objectives, then monthly or more frequent sampling will be performed until the cause is determined. If a corrective action is required, then monthly effluent sampling will continue for at least three months after a corrective action is implemented to ensure that the action is sufficient.

Based on preliminary calculations provided by CDPHE, the current stream standard will be achieved if effluent concentrations are 500 mg/L. Effluent concentrations are expected to achieve this level. These preliminary calculations indicate that effluent concentrations must meet 50 mg/L to achieve surface water standards after 2009. Decision rules will be refined as performance monitoring trends are established and in anticipation of the decrease in the stream standard from 100 mg/L to 10 mg/L after 2009.

Groundwater monitoring will continue during and after the remedial action has been completed, as described in the IMP. Groundwater wells 1786 and 1386 currently monitor the drainage and will be, at a minimum, monitored for nitrate and uranium. An additional well cluster to the north of the barrier will be installed to provide additional data and for performance monitoring purposes. The frequency of sampling and analytical suites will be consistent with the IMP and will measure uranium and nitrate concentrations.

Performance monitoring in the North Walnut Creek Drainage will be implemented at station GS13 to monitor changes in surface water quality as a result of the selected remedy. This location was selected because it is immediately downstream of where the groundwater plume intersects the drainage. The loading to the stream will be evaluated to determine long-term system performance and will be reported on an annual basis. In accordance with the Action Level Framework, if the stream concentrations exceed stream standards, then an evaluation will be performed after consultation with the regulators.

If stream standards are being met consistently at GS13 and if simple modeling techniques show that the stream standards would be met without treatment, based on the influent plume concentrations and flow rate, and the stream concentrations and flow rate that exist at that time, then treatment will be discontinued. This system is expected to continue operations until after Site closure when stream flow and concentrations have stabilized. The system will be abandoned in place as a flow-through system. System shutdown will be re-evaluated as part of the final Site CAD/ROD.

5.6 Air Monitoring

The K-H Air Quality Management group maintains the RFETS Radioactive Ambient Air Monitoring Program (RAAMP) which monitors the perimeter of RFETS continuously with samples collected and analyzed on a monthly basis. The RAAMP sampling network also includes monitoring stations inside the perimeter of RFETS which are collected but not analyzed unless conditions warrant additional analysis.

Wind speed and direction are monitored continuously at RFETS and these data are available through the shift superintendent. Dust suppression will be performed to minimize the potential for particulate dispersion.

5.7 Waste Management

When the excavation for the placement of the impermeable barrier is performed, soil will be stockpiled adjacent to the trench for use as backfill or to re-grade the area, if appropriate. If water accumulates in the trench during excavation and poses a threat to the excavation progress, the water will be transferred to the MSTs, if appropriate. Any associated collected sediment will be segregated, mixed with backfill material to make it more manageable for handling, and returned to the trench, if appropriate.

The treatment system will contain reactive media that has a limited life and will need replacement during the operational life of the system. When the treatment capacity of the media is exceeded, it will be replenished, or removed and replaced. The spent media will be stored and managed based on analytical results (i.e., the spent media will be evaluated to determine whether it is a hazardous waste, and will be managed accordingly and disposed of appropriately). It is anticipated that the media will require replacement every five to ten years.

6.0 ENVIRONMENTAL EVALUATION

Incorporation of environmental values into Site decision documents is mandated in the RFCA. This Decision Document is a major modification to the *Final Proposed IM/IRA Decision Document for the SEPs, OU 4*, and therefore is included in that requirement by RFCA. Accordingly, this section provides a description of potential environmental impacts associated with the remediation of groundwater at the SPP.

6.1 Soils and Geology

When the Reactive Barrier System is installed, the impacts would include irreversible loss of surface soils, subsurface deposits, and weathered bedrock. The losses would extend the length, width and breadth of the new collection trench to be installed on the north side of the North Access Road. Construction of this trench would necessitate removing 800 feet of surface soils, subsurface deposits, and weathered bedrock to a depth of 20 to 30 feet deep, extending about 10 feet into the weathered bedrock. While soils would be removed and ultimately replaced after drainage pipes were installed, the disturbance would result in a permanent alteration to the geology of the area.

6.2 Air Quality

Non-radiological air quality impacts from the stated proposed action are limited to the construction period, and consist primarily of heavy equipment emissions and dust created during the installation of the Reactive Barrier System. The Colorado Air Quality Control Commission requires that practical, economically reasonable, and technologically feasible work practices be used to control emissions. Techniques such as using water sprays and stopping work during high wind periods (typically winds exceeding 15 mph) would be used. If fossil fuel fired generators or other portable equipment would be needed, opacity standards (20 percent) must be met, and fuel usage tracked for the duration of the project. Heavy equipment (e.g., trenchers, bulldozers, front-end loaders and dump trucks) would be used. The impacts from these pieces of equipment, and from the construction of the trench itself, are short-term, and with the use of proper dust suppression techniques, controllable.

Radiological concerns would also be associated with dust emissions generated during soil disturbances. An application for approval is required to be filed with the U.S. EPA and Colorado Department of Public Health if emissions would cause the most impacted member of the public to receive an effective dose equivalent (EDE) of 0.1 millirem per year (mrem/yr). Based on sampling, the soils to be excavated contain very low concentrations of radionuclides. Using conservative assumptions (i.e., all excavated soil is assumed to contain the greatest activity of radionuclides as determined through analytical testing of trench-area soil samples), the estimated total uncontrolled EDE to the most impacted member of the public would be 2.2E-03 mrem/yr, and would not exceed the 0.1 mrem/yr EDE threshold during the construction of the trench.

6.3 Water Quality

Water quality in the North Walnut Creek drainage will be protected by removing the contaminants of concern from groundwater using a system to treat contaminated groundwater and recharging clean water to the aquifer. Construction activities could adversely impact water quality through erosion. Silt fences will be used to prevent eroded soils from reaching North Walnut Creek.

56

Water flow in the aquifer and from the aquifer to the creek may increase as a result of installing the treatment system. Water currently pumped to Building 374 for evaporation will remain in the North Walnut Creek drainage, maintaining more natural stream flows.

6.4 Human Health and Safety

The implementation of this project could expose workers to physical, chemical and low-level radiological hazards. As discussed in Section 5.3, these hazards will be considered and controlled during all phases of the project. The use of controls and procedures for worker protection will also protect the public, since work control measures are designed to identify potential hazards and prevent releases of all types (e.g., dust control; decontamination of excavation equipment).

6.5 Ecological Resources

The proposed alternative would affect vegetation and wildlife both during construction and after the project is complete. Use of the passive reactive barrier treatment system rather than the flash evaporators for treatment of water collected by the ITS would increase water flow into areas inhabited by the Preble's Meadow Jumping Mouse, a federally-listed threatened species.

Peripheral areas of the habitat for Preble's Meadow Jumping Mouse would be disturbed by installation of the Reactive Barrier System. The use of silt fencing and RFETS procedures for revegetation would minimize the possibility of adverse effects. Construction activities could cause erosion on the hillside and soil deposition in the habitat area. Because the proposed construction site is just north of an already disturbed area in use as an access road, limited impact is expected from construction in the area. Disturbed areas would be revegetated with native grasses, replacing the non-native smooth brome grass found in the area.

6.6 Historic Resources

The Rocky Flats Plant site was placed on the National Register of Historic Places as a Historic District (5JF1227) on May 19, 1997. Historic District designation mandates compliance with the Historic Preservation Act of 1966, and the Programmatic Agreement among RFFO, Colorado State Historic Preservation Officer, and the Advisory Council on Historic Preservation Regarding Historic Properties at RFETS. While the Reduced Infiltration/Wetlands Treatment project site would be within the Historic District boundaries, no impact is expected to occur to protected structures. In the unlikely event that potentially historic artifacts are encountered, appropriate site procedures would be followed.

6.7 Visual Resources

When the Reactive Barrier System is installed north of the North Access Road, construction activities will be visible to RFETS visitors. The proposed activities would be similar to those commonly encountered with highway and drainage construction activities.

6.8 Noise

The noise levels may be elevated during construction of the Reactive Barrier System. Noise levels would not exceed those commonly encountered at a highway construction site. Appropriate hearing protection would be supplied for project personnel as identified in the project's HASP.

6.9 Cumulative Effects

The overall effect of the SPP groundwater remediation activities is expected to be beneficial. A long-term reduction of groundwater contamination would result, as well as an increase in flow to North Walnut Creek.

Prevention of groundwater contamination is part of the overall mission to clean up the site and make it safe for future uses. The cumulative effects of this broader, site-wide effort are described in the *Cumulative Impacts Document*, (DOE, 1997a). That document describes the short- and long-term effects from the overall site clean-up mission.

6.10 Unavoidable Adverse Effects

Some temporary, adverse effects would necessarily occur because of the project activities. Some vegetation would be destroyed, and animals may be temporarily dislocated. Soil conditions in disturbed areas would be changed. Noise levels would increase slightly and temporarily. Fuels and other resources would be consumed, and some minor quantities of air pollutants from construction equipment would be released to the atmosphere. Dust generated during field work would adversely affect air quality.

6.11 Short-term Uses Versus Long-Term Productivity

The project area is currently vacant. Project activities would improve water quality, and would give the potential for other, possibly more productive, uses after Site closure activities are completed.

6.12 Irreversible and Irretrievable Commitments of Resources

This project would irretrievably consume fuels and small quantities of materials in construction of the Reactive Barrier trench. None of these resources would be consumed in quantities that are significant relative to their consumption elsewhere across the Site. The project will not irreversibly affect natural resources.

7.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

RFETS accelerated actions performed must attain, to the maximum extent practicable, federal and state applicable or relevant and appropriate requirements (ARARs). For that reason, the substantive attributes of the federal and state ARARs must be identified. However, section 121(e)(1) of Comprehensive Environmental Response Compensation and Liability Act (CERCLA) waives the procedural requirement to obtain federal, state, or local permits (RFCA ¶16.a.).

The groundwater treatment unit and discharge will be located in the buffer zone. For each permit waived, RFCA requires identification of the substantive requirements that would have been imposed in the permit process (RFCA ¶17). Further, the method used to attain the substantive permit requirements must be explained (RFCA ¶17.c.). The following discussion is intended to compliment other portions of this Decision Document in a manner that satisfies the RFCA permit waiver requirements.

7.1 Chemical-Specific Requirements and Considerations

7.1.1 Colorado Water Quality Standards

For the contaminants of concern, the site-specific Colorado Water Quality Standards for Segment 5 of Big Dry Creek are applicable to the segment of North Walnut Creek that will be impacted by groundwater treatment unit and discharge. The site-specific water quality standards are identified in the RFCA Action Level Framework (ALF), Table 1. These water quality standards are also relevant and appropriate to developing a design that will capture, to the maximum extent practicable, the groundwater that exceeds the surface water action levels. (See 5 CCR 1002-38, Classification and Numeric Standards South Platte River Basin, Section 38.6, Segment 5, Big Dry Creek). The surface water quality standards for the contaminants of concern are presented in Table 7-1.

Table 7-1. Big Dry Creek Segment 5 Surface Water Quality Standards.

Nitrate, as N	100 mg/L[1]
Uranium	10 pCi/L[2]

[1] Temporary Modification, effective from 3/97 to 12/09
[2] Ambient Standard

7.1.2 National Emissions Standards for Hazardous Air Pollutants (NESHAP)

Title 40 of the CFR Part 61, Subparts A and H (Colorado Code of Regulations [CCR] 5 1001-3, Regulation No. 8, Part A, Subparts A and H) contain the applicable NESHAPs. This regulation requires limiting RFETS radionuclide emissions to meet an annual public dose standard (to offsite member of the public) of 10 millirem (mrem); monitoring significant emissions points; notifying EPA/CDPHE and obtaining approval (state permit) prior to construction or modification of radionuclide sources with emissions exceeding a 0.1 mrem threshold; and annual reporting of the RFETS EDE for each calendar year to demonstrate compliance with the 10 mrem standard.

Due to low concentrations of radionuclides in groundwater, surface and subsurface soils, and because the proposed remediation is a CERCLA project, EPA/CDPHE notification and approval are not required. The estimated dose from the project (2.2E-03 mrem/yr) does not expected to exceed the 0.1 mrem monitoring threshold. (See 40 CFR §61.93 (b)(4)(i)). Records will be kept, as needed, of project parameters sufficient to estimate the dose for annual compliance reporting.

7.2 Action-Specific Requirements and Considerations

The following action-specific requirements and considerations were evaluated specific to SPP:

- Definition of Remediation Waste
- Identification and Listing of Hazardous Wastes
- Land Disposal Restrictions (LDR)
- Construction Waters
- Soil Staging
- Temporary Unit Tank and Container Storage
- Particulate, VOC and Hazardous Air Pollution Emissions
- Debris Treatment
- Water Treatment Unit

7.2.1 Remediation Waste

In RFCA remediation waste is defined as all:

> *(1) Solid, hazardous, and mixed wastes;*
> *(2) All media and debris that contain hazardous substances, listed hazardous or mixed wastes or that exhibit a hazardous characteristic; and*
> *(3) All hazardous substances generated from activities regulated under this Agreement as ... CERCLA response action.... (See RFCA ¶25.bf.).*

A parallel definition is also found in 40 CFR §260.10. As such, the definition of remediation waste is applicable to all wastes, environmental media (soil, groundwater, surface water, storm water and air) and debris generated in conjunction with this action.

7.2.2 Identification and Listing of Hazardous or Toxic Substances Control Act Waste

Requirements governing the identification and listing of hazardous wastes are applicable to this action. (See 40 CFR Part 261). Based upon process knowledge and characterization data from the SPP and ITS, the contaminated groundwater and soil that will be addressed during this action does not contain hazardous constituents. For that reason, it is assumed that no hazardous waste listing is applicable to any groundwater, soil, or debris generated during the construction or operation of the proposed action. However, if such waste is encountered, it will be managed according to the substantive requirements of the regulations. Additionally, no polychlorinated biphenyl (PCB) wastes are anticipated; however, if PCB wastes are generated they will be managed in accordance with the substantive requirements of 40 CFR Part 761.

7.2.3 Wastewater Treatment Unit

The Clean Water Act, National Pollution Discharge System (NPDES) governs the discharge of pollutants from any point source into the waters of the United States. (See 40 CFR §122.1(b)). The discharge from the treatment unit is governed by the NPDES permit waiver described in Section 7.0. Therefore, the discussion in this section is provided to satisfy ¶17 of RFCA. The surface water quality standards (see

Table 7.1 section 7.1.1) are relevant and appropriate to the treatment unit discharge. The treatment unit will be designed and operated such that water quality will not exceed the standards identified in Table 7-1 in North Walnut Creek downgradient of the system. No NPDES action-specific ARARs addressing the design or operation were identified.

7.2.4 Land Disposal Restrictions

The Land Disposal Restriction levels for wastewater or non-wastewaters are applicable to any remediation waste that exhibits a hazardous waste characteristic or contains listed hazardous waste if it is actively managed outside of the area of contamination. If any hazardous waste is encountered during construction, it will be managed according to the substantive requirements of the regulations.

7.2.5 Construction Waters

Water collected during construction activities will be diverted to the MSTs, as necessary, which are presently used to store water collected from the ITS.

7.2.6 Soil Staging

The movement and temporary staging and replacement of excavated soils will be consistent with the General Stormwater Permit for Constructions activities, Best Management Practices (BMPs) to control erosion. Common BMPs include silt fences or hay bales. Deeper, more contaminated soils will be benched within the excavation. This will ensure that sediments and contaminants are contained within the working area.

7.2.7 Temporary Unit Tank and Container Storage

Tanks and containers may be used during construction and startup to contain groundwater that may seep into the construction area. The use of containers for such waste does not require a temporary unit because the groundwater does not contain hazardous constituents. If any hazardous waste is encountered, it will be managed according to the substantive requirements of the regulations.

7.2.8 Air Pollutant Emissions (Particulates, Volatile Organic Compounds, and Hazardous Air Pollutants)

Soil excavation activities for this project have the potential to generate radioparticulate and fugitive dust emissions. Radionuclide air pollutant emissions are regulated by 40 CFR 61, Subpart H (Radionuclide-NESHAP) and 5 CCR 1001-3 Regulation No. 8. The regulatory reporting and monitoring requirements and radionuclide-standard limitations set forth in these regulations are discussed in Section 7.1.2.

Fugitive particulate emissions will be generated during construction activities. Estimated emissions are below air emission inventory reporting thresholds and are based on the volume of soil to be excavated (i.e., a total of 23,611 cubic yards), stockpiled, and backfilled. 5 CCR 1001-3, Regulation No. 1 requires the implementation of practical, economically reasonable, and technologically feasible work practices to control particulate emissions. During soil handling activities, dust minimization techniques such as water sprays, will be used to minimize suspension of particulates. In addition, earth moving operations will not be conducted during periods of high wind. The substantive requirements of a control plan (Regulation No. 1, Section III.D) will be included in project documentation. In addition, RFETS Environmental Restoration

Field Operations Procedure FO.1, Air Monitoring and Particulate Control, requirements are incorporated into project operations.

5 CCR 1001-3, Regulation No. 7, regulates VOC emissions. Regulation No. 7, Section II requires new sources of VOC to utilize reasonably available control technologies (RACT). VOCs may be emitted during soil excavation; however, based on maximum concentrations of VOCs, less than 500 μg/Kg total were detected in trench area soils (DOE, 1995). As a result, significant VOC concentrations are not expected. A bounding assumption has been made that less than 1 ton of VOCs will be emitted from excavation and soil handling activities. Based on this assumption, RACT will be attained without implementing specific VOC controls for soil excavation, staging and replacement (See Statement of Basis and Purpose, Regulation No. 3, Part D, July, 15, 1993).

Regulation No. 7, Section III governs the transfer and storage of VOCs and requires bottom or submerged fill for containers greater than 56 gallons. CDPHE has previously given guidance that any liquid containing any amount of an organic compound may be considered a VOC for purposes of this requirement. This requirement is applicable to containers and tanks larger than 56 gallons used to dewater the excavation or used to manage decontamination water. To the maximum extent practicable, storage tanks and related equipment must be maintained to prevent detectable vapor loss.

5 CCR 1001-3 Regulation No. 3, provides authority to CDPHE to inventory air pollutant emissions. Part A, Section II of this regulation requires the submittal of Air Pollution Emission Notices (APENs) to CDPHE prior to initiation of the Solar Ponds Plume project if regulatory inventory thresholds are exceeded. Based on conservative assumptions concerning soil-contaminant concentrations (i.e., the maximum activity detected in surface soil for each radionuclide as summarized on Table 2-1) and project parameters, estimated potential emissions will not exceed inventory-reporting thresholds, so APENs do not need to be submitted to CDPHE. As stated in Section 6.2, the soils to be excavated contain very low concentrations of radionuclides. Using conservative assumptions (i.e., all excavated soil is assumed to contain the greatest activity of radionuclides as determined through analytical testing of trench-area soil samples), the estimated total uncontrolled EDE to the most impacted member of the public would be 2.2E-03 mrem/yr, and would not exceed the 0.1 mrem/yr EDE threshold during the construction of the trench.

Project operations may require limited use of fossil-fuel fired generators or other portable equipment. The potential combustion-product emissions from temporary use of these units will not exceed APEN inventory reporting thresholds. All fossil-fuel fired units will comply with the 20% opacity standard set forth in 5 CCR 1001-3, Section II.

7.2.9 Debris Treatment

During construction activities, it is expected that some debris and construction waste will be generated. None will be considered hazardous waste.

7.3 Location Specific Requirements and Considerations

7.3.1 Endangered Species Act

The Endangered Species Act, 50 CFR Part 17, and the Colorado Nongame, Endangered, or Threatened Species Conservation Act, CRS 33-2-101, et seq. are relevant and appropriate because the action has the potential to affect critical habitat for Preble's Meadow Jumping Mouse. However no long-term or adverse impact is anticipated and applicable RFETS site procedures and DOE orders will be implemented to ensure attainment of these ARARs. The Fish and Wildlife Service has been consulted and has concurred with the assumption that implementation of the proposed alternative will not adversely affect the Preble's Meadow Jumping Mouse.

7.3.2 Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act, 16 USC §661 is not applicable because there will be no modification to the wetlands or alteration of a flowing stream with the potential to impact wildlife. The Fish and Wildlife Service has been consulted as required by the Memorandum of Understanding between the DOE and the Fish and Wildlife Service prior to initiation of the proposed action.

7.3.3 Wetland Assessment

Pursuant to Executive Order 11990, and 40 CFR Part 6 Appendix A, federal agencies must prevent, to the extent possible, the adverse impacts of destroying or modifying wetlands and must prevent direct or indirect support of new construction in wetlands if there is a practicable alternative. These requirements are not applicable to the Solar Pond Plume action because no wetlands will be disturbed during implementation of the proposed action.

8.0 IMPLEMENTATION SCHEDULE

Installation of the collection/treatment system for the SPP is scheduled to commence in June 1999, and system startup is anticipated to begin within 4 months of start of construction. Any delays, scope, or budget changes may affect this schedule. The groundwater collection and treatment system is expected to be the long-term remedy for the SPP. The system is expected to operate as long as it is required to meet the original objectives.

9.0 REFERENCES

Crawford, B. and Stevanak, T., 1993, *A Subsurface Contaminant Transport Model for the Unconfined Movement of Uranium form the Solar Evaporation Ponds (OU4), Rocky Flats Plant; Golden, Colorado.*

DOE, 1992, The *Final Proposed IM/IRA Decision Document for the SEPs, Operable Unit 4*

DOE, 1994, *Final Phase II RCRA RFI/RI Work Plan, OU4, SEPs*, RF/ER-94-00040, U.S. DOE, RFETS, September

DOE, 1995, *OU4—SEPs, IM/IRA Environmental Assessment Decision Document*, U.S. DOE, RFETS, February

DOE, 1996, Rocky Flats Cleanup Agreement

DOE, 1997, Rocky Flats Cleanup Agreement, Appendix 3, RF/RMRS-97-043, August.

DOE, 1997a, *Cumulative Impacts Document,* Rocky Flats Field Office, Golden, Colorado, June 10, 1997.

EG&G, 1995a, *Geologic Characterization Report for the Rocky Flats Environmental Technology Site,* Volume I of the Sitewide Geoscience Characterization Study, EG&G Rocky Flats, Golden, Colorado, March.

EG&G, 1995b, *Hydrogeologic Characterization Report for the Rocky Flats Environmental Technology Site,* Volume II of the Sitewide Geoscience Characterization Study, EG&G Rocky Flats, Golden, Colorado, April.

ERM, 1996, *OU4 SEPs, Phase II Ground Water Investigation, Final Field Program Report,* ERM, February 1996

Grigsby, 1998, Personal Communication F. Grigsby, RMRS.

Honeyman, Bruce D. and Santschi, Peter H., 1997, *Actinide Migration Studies at the Rocky Flats Environmental Technology Site*, December.

Hydrogeologic, 1996, Visual MODFLOW, Version 1.5, The Integrated Modeling Environment for MODFLOW and MODPATH, Waterloo Hydrogeologic Software, January.

Kaiser-Hill (K-H), Inc., 1996, Rocky Flats Environmental Technology Site Radiological Control Manual, June 1, 1996.

RMRS, 1996, *Management Plan for the ITS Water*, RF/ER-96-0031.UN, Rocky Mountain Remediation Services

RMRS, 1997a, *SPP Remediation and ITS Water Treatment Study*, RF-RMRS-97-093.UN, Rocky Mountain Remediation Services

65

RMRS, 1997b, *Sampling and Analysis Plan for Groundwater Sampling and Well Installation in the SPP Area, RF/RMRS-97-136*, February

RMRS, 1997c, *Sampling and Analysis Plan for Vegetation in the Area of the SPP*

RMRS, 1997d, *Sampling And Analysis Plan For Soils In The Area Of The SPP,* RF-RMRS-97-128

USGS, 1994, MODPATH, United States Geological Survey

66

APPENDIX A: ALTERNATIVE ANALYSIS

A.1 Introduction

This appendix presents the process used to select reactive barrier as the preferred alternative to address the SPP. Previous to this effort, an alternative screening for the SPP was documented in the *SPP Remediation and ITS Water Treatment Study* (RMRS, 1997a). Four alternatives were selected for further consideration:

- Managed Release,
- Treatment at Building 995,
- Phytoremediation, and
- Enhanced Evaporation

The screening of alternatives was performed a second time to reflect: 1) changes in selection criteria, 2) a technical evaluation of phytoremediation, 3) a treatability study on 995 operation, and 4) recent technical information on zero-valence iron. As described in Section A.3, the following five technologies were selected in the second screening for final comparison:

- No Action,
- Managed Release
- Treatment at Building 995
- Phytoremediation, and
- Reactive Barrier

This appendix presents the criteria used to screen and compare alternatives, the second screening of alternatives, a final comparison of alternatives and the final selection of an alternative. The alternative analysis is organized as follows:

A.1 Introduction

A.2 Selection Criteria - The section contains the revised criteria used for a second alternative screening and the final comparison of alternatives. Although modifications were made to reflect more recent data, the criteria still conforms to RFCA, Appendix 3, RFCA Implementation Guidance Document (DOE, 1997).

A.3 Alternative Screening - This section contains the second screening of the alternatives based on the revised criteria.

A.4 Description of the Final Alternative - This section contains descriptions of the five final alternatives to be analyzed in the final comparison of alternatives.

A.5 Final Comparison of Alternatives - This section consists of the final comparison of the five, screened alternatives and the selection of the best alternative to address the SPP.

61

A.2 Selection Criteria

The two-step alternative selection process described in the *RFCA Implementation Guidance Document* (DOE, 1997) was used to select the best alternative. This process consists of an initial screening to select the best alternatives followed by a comparative analysis of the alternatives. Both the screening and the comparative analysis are based on the three following criteria:

1) **Effectiveness** - Includes protectiveness of public health, workers, and the environment, ability to attain ARARs, the level of treatment/ containment, residual effect concerns, and the ability to maintain protectiveness on an long-term basis. The ability to remove or immobilize both nitrates and uranium was considered when evaluating effectiveness.

2) **Implementability** - Includes the technical feasibility, availability of resources, and administrative feasibility. It also includes implementability based on land-use restrictions due to Preble's Mouse habitat.

3) **Cost** - Includes capital costs, operation costs, maintenance costs, and present worth analysis. Operation and maintenance costs are assumed to include sampling and analysis. Waste disposal costs, aside from some transportation and sampling costs, are not included in the estimate. Costs are escalated five percent for outyears.

NEPA values played an important role in alternative selection. In particular, new emphasis was placed on preserving the habitat of Preble's Meadow Jumping Mouse (Preble's Mouse), a threatened species under the Endangered Species Act. The habitat lies north of the Solar Ponds along the North Walnut Creek drainage. The habitat plays an important role in the decision making process because it affects both the effectiveness (through the alternatives ability to attain ARARs and to be protective of the environment) and the implementation of an alternative (feasibility of an alternative is restricted by the defined habitat of Preble's Mouse).

Emphasis was also placed on alternatives that would serve as a long-term solution, hence, more emphasis on passive remediation methods were favored. A long-term approach is defined as an approach that can effectively mitigate the contaminants indefinitely, after plant systems are shut down and RFETS has undergone closure. Additionally, the alternatives were reevaluated based on their ability to remove both nitrates and uranium.

A.3 Alternative Screening

The second screening of alternatives was limited because many of the alternatives were not implementable based on the new criteria and the screening results are shown on Table A-1. No alternative was selected that would destroy Preble's Mouse habitat and/or consisted of a non-passive treatment system. This eliminated the following alternatives from future consideration in the screening process:

- Evaporation at Building 374
- Treatment at MSTs
- Constructed Wetland
- Off-Channel Evaporation Pond
- Enhanced Evaporation

- Dispersion Field (Leach Field)
- Early Capping of the Solar Ponds
- Enhanced ITS
- Recirculating Water to Solar Ponds
- Injection of Organic Liquids
- Ex Situ Metal Treatment Process
- Denitrification Unit at ITS Pump House
- Pave the ITS

Table A-1. Screening of Alternatives for Solar Pond Plume.

Alternative	Description	Screening Results
1) No Action (Direct Release)	No action is defined as no collection and no treatment of groundwater. Abandonment of the ITS would be included under this option. The no action alternative supports the requirements of NEPA for remedy selection.	**Selected** – Low cost, meets NEPA requirements for alternative analysis, does not effectively treat contaminants
2) Managed Release	Construct a pipeline to redirect flow from ITS to Pond A-4. When a surface water standard for nitrate of 100 mg/l is implemented, the ITS would be abandoned in place and groundwater would flow directly into North Walnut Creek.	**Selected** – Meets surface water requirements, not as disruptive to Preble's Mouse habitat, low cost
3) Treatment at Building 995	Continued use of the ITS and the MSTs. Water would be transferred to the STP(Building 995) instead of Building 374 evaporator.	**Selected** – Modifications are simpler to implement, not as disruptive to Preble's Mouse habitat although the cost is high
4)Phytoremediation	Use of deep-rooted vegetation to passively intercept and treat SPP.	**Selected** – Long term approach, highly effective on nitrate, Disruptive to Preble's Mouse habitat
5) Reactive Barrier	Reactive barrier utilizing zero-valence iron and an organic media to reduce the uranium and the nitrate. ITS would back up system to ensure nitrate removal.	**Selected** - Effective system for uranium removal, not as disruptive to Preble's Mouse Habitat
6) Evaporation at Building 374	This is a continuation of current interim action. Water from the ITS is pumped to the MSTs and then to the Building 374 evaporator.	**Screened Out** - Not a long-term approach because it relies on the continued operation of the 374 evaporator
7) Treatment at MSTs	A 30-gallon per minute treatment system utilizing chemical precipitation, membrane filtration, and biodenitrification.	**Screened Out** - High Cost, Requires the construction of a new treatment system when existing systems at 995 and 374 could be used. Potential to greatly disturb Preble's Mouse Habitat, not a long-term solution

69

Table A-1. (continued).

Alternative	Description	Screening Results
8) Constructed Wetland	Under this alternative a wetland would be constructed away from the A-Series ponds.	**Screened Out** – Would be disruptive to Preble's Mouse habitat
9) Off-Channel Evaporation Pond	Water is sent to a lined evaporation pond in the buffer zone instead of the MSTs. The pond would be approximately 4-5 acres.	**Screened Out** - would require use of undisturbed land, would impact Preble's Mouse habitat, not a long-term solution since closure would have to be done eventually on the evaporation pond
10) Enhanced Evaporation	MSTs would be utilized as evaporators. 132 spray nozzles would be installed at the top of each MST. Pumps would circulate the water. Enhanced evaporation would occur because the air to water interface area would be improved.	**Screened Out** - not a long-term approach, requires freeze protection
11) Dispersion Field (Leach Field)	Water is pumped from the MSTs to a leach field outside of the North Walnut Creek drainage. Leach field would be constructed out of 54 rows of parallel trenches.	**Screened Out** – would likely contaminate clean soil and water, not effective on uranium
12) Early Capping of the Solar Ponds	Place a cap on the Solar Ponds as an Interim Action to reduce groundwater flow and the mass flux of the contaminants	**Screened Out** – High cost, would not treat contamination in the groundwater, would not intercept plume, could be combined with another alternative
13) Enhanced ITS	Excavate the ITS and place collection pipe system about ten feet into bedrock.	**Screened Out** – Passive only if combined with a passive technology, would impact Preble's Mouse habitat
14) Recirculation of Water to Solar Ponds	Pump ITS water back into Solar Ponds	**Screened Out** – Did not work before, would cause slope stability problems, does not treat the water
15) Injection of Organic Liquids	An organic liquid such as molasses or acetic acid would be injected into the nitrate plume	**Screened Out** – Organics would increase biological oxygen demand in stream, ecosystem could be damaged by residual liquids
16) Ex Situ Metal Treatment Process	An ex situ treatment system using reactive iron would be used to reduce the nitrates.	**Screened Out** – Not a long-term solution, could generate trace amounts of other contaminants, non passive

70

Table A-1. (continued).

Alternative	Description	Screening Results
17) Denitrification Unit at ITS Pump House	A mobile treatment unit that would denitrify the water using sewage treatment technologies.	**Screened Out** – Non-passive, not a long-term solution, high annual operating cost
18) Pave the ITS	Eliminate surface water flow into the ITS by paving over the most south collection trench since it is design to capture run-off.	**Screened Out** – Does not treat or intercept existing plume, could be combined with another alternative

The exception to this is the utilization of the Building 995 sewage treatment system, which although is not a long-term solution, was carried through the screening phase based on the availability and minimal impacts to environmentally sensitive areas.

Enhanced evaporation was not originally screened out in the initial screening in the SPP remediation and ITS water treatment study (RMRS, 1997a). However, it was screened out in this decision document because it did not present a long-term solution, the instability of the MST system, and the potential for freezing. The reactive passive barrier (originally iron/peat passive treatment) was not screened out because it is effective on uranium and nitrates, and it is a long-term solution. A no-action (direct release) alternative was considered to meet NEPA requirements. The five technologies selected for the comparative analysis of alternatives and summarized in Table A-1 then become:

- No Action,
- Managed Release
- Treatment at Building 995
- Phytoremediation, and
- Reactive Barrier

A.4 Description of Final Alternatives

A.4.1 Alternative 1 - No Action

The no-action alternative is defined as no new action as well as a cessation of previous interim remedial actions. Specifically, the ITS, MSTs, Interceptor Ditch Pump House, and associated fixtures and pipelines would be deactivated and decommissioned. This alternative is identical to the Direct Release Alternative in the *SPP Remediation and ITS Water Treatment Study* (RMRS, 1997a). Surface water and groundwater would flow into North Walnut Creek through natural conveyances. Because the ITS system would be grouted as part of deactivation, it would remain a partial impediment to groundwater flow and plume migration; however, once steady-state conditions have been met, the effectiveness of the ITS as a barrier will likely be negligible. Prior to implementing grouting of the ITS, the impacts will be analyzed to ensure that it does not force the groundwater plume into previously uncontaminated areas.

A.4.2 Alternative 2 - Managed Release

Under this scenario, untreated ITS water would be released to North Walnut Creek. During Phase I the interim nitrate surface water standard of 100 mg/L is in place. Pumping at the ITS pump house would cease and the ITS water would be allowed to flow from the pump house to North Walnut Creek. During Phase II, the ITS would be decommissioned by grouting after capping of the Solar Ponds in 2005.

Technical evaluation of the impacts of Phase I on North Walnut Creek indicated that the nitrate and uranium surface water standards would be met on a seasonal basis. However, there would likely be times during low flow periods when the surface water standards of North Walnut Creek would not be met. The effectiveness of Phase II was evaluated as part of the groundwater assessment and modeling activities. It is suspected that North Walnut Creek would not meet the surface water standard for nitrate of 10 mg/L. The primary drawback to this remedial alternative, is its inability to meet the surface water standards on a daily basis as required by RFCA.

A.4.3 Treatment of ITS Water at Building 995

ITS water would be pumped to the STP (Building 995) rather than to the evaporators at Building 374. Redirection of the ITS water to Building 995 would involve very little modification to the Site's infrastructure as most of the necessary components are in place and useable. The 995 treatment system would require modifications to address the influx of water. Specifically, methanol would need to be added to the input stream to support the biological reduction of nitrates. Water would be sent to the RFETS STP either by routing it through the existing line that runs from MSTs to the Building 374 Evaporator or by tying into a line that runs from the Solar Ponds area to Building 910 where it would be diverted to the sanitary sewer. The ITS water is expected to have a major impact on operations at the facility since it would require operators to be present around the clock. Treatability studies were performed to assess the impacts of the ITS water on the current operating process, as well as impacts to the proposed on/off aeration system for this building were suggested. Evaluation of the potential impact of the uranium in the ITS water on the possible future land application of STP biosolids was also conducted.

A.4.4 Phytoremediation

Phytoremediation is an emerging soil, groundwater, and wastewater remediation technology that makes use of designed plant systems to remove, contain, or change the form of metals, organic, and radioactive compounds. Phytoremediation systems can be active (irrigated with contaminated water) or passive (deep-rooted plants draw water directly from contaminated aquifer). A study was conducted in which both active and passive systems were evaluated; the passive system was selected as the best approach to meet the long-term objectives of the IM/IRA. The passive system will focus on minimizing recharge of contaminated SPP groundwater to North Walnut Creek. This passive phytoremediation system will involve planting of deep-rooting native vegetation in the SPP upgradient of North Walnut Creek to intercept shallow groundwater. The Preble's Mouse, a species recently listed as threatened, lives in the riparian areas along North Walnut Creek. To protect the Preble's habitat, only native vegetation will be planted in any phytoremediation system implemented, and this will be outside of the designated Preble's habitat.

The selected vegetation would likely be a native cottonwood tree (*Populus spp.*). Initially, the trees will be irrigated to establish the trees and train the root systems for maximum interception of plume flow. It is anticipated that four years will be required for the trees to become mature enough to survive without irrigation and provide control of the SPP. Review of published research indicates that phytoremediation using cottonwood trees will be highly effective in reducing nitrate concentrations in groundwater. The fate of the dissolved uranium in the groundwater after implementation of a phytoremediation system is unclear.

A.4.5 Reactive Barrier

The reactive barrier consists of a cut-off trench that would direct the water through treatment cell(s) filled with zero-valence iron and a carbon source such as peat or sawdust that would immobilize the uranium through chemical reduction. Nitrates would also be reduced; however, a treatability study is needed to determine effectiveness and reaction products. The treatability study would also be needed to determine more definitive design specifications such as the volume and width of the zero-valence iron, residence time, the effect of a carbon source on denitrification, and to quantify the effectiveness on uranium. Because it is a passive system and the iron/organic media would not significantly alter the overall hydraulic conductivity, it was assumed that trench would be approximately 850 feet long which is the required width to capture the Tier II nitrate plume. The trench would be installed north of the North Access Road which is just north of the Protected Area on the north side of the Solar Ponds to the south of the protected area fence. Under this alternative, a graded approach towards remediation would be used. Water from the ITS would be initially sent to the Building 374 evaporator as is the current practice. Based on the treatability studies, it will be determined whether to keep pumping the ITS, use in situ biological treatment, or an ex situ treatment system just north of the ITS sump. If it appears that an ex situ treatment system at the based of the ITS sump is necessary, then this work will be initiated immediately to take advantage of the hibernation period of Preble's Mouse.

A.5 Comparative Analysis of Alternatives

A.5.1 Alternative 1 - No Action

<u>Effectiveness</u>

There is no reduction in toxicity, mobility, or volume of contamination except through natural attenuation. This alternative is not as effective as other alternatives. Long-term effectiveness could be better than short-term effectiveness because caps planned for the Solar Ponds could reduce the flow through contaminated areas. This cumulative effect will not significantly change the flow in the North Walnut Creek Drainage; however, it will reduce the exposure of groundwater and surface water to potential sources which will ensure a greater degree of protectiveness for the public and the environment since contaminant concentrations should decrease.

This alternative possibly could comply with ARARs; however, treatment or monitoring surface water standards could potentially be exceeded, in particular, North Walnut Creek might not meet the surface water standard for nitrate of 10 mg/L. It does not appear to have a direct impact on Preble's Mouse habitat.

<u>Implementability</u>

There is no remedial action, so there are no immediate implementation problems. The ITS would need to be grouted; however, this task could have a fairly open schedule and few impacts.

<u>Cost</u>

The cost for this alternative is very minimal. The costs consist of a one time capital cost of $107, 000 for decommissioning the existing ITS system plus an additional cost of $100,000 for groundwater assessment. This estimate was developed as part of the original screening presented in RMRS (1997a) on page 3-5.

13

For comparison purposes, twenty-five years was used for operational life of all alternatives. Table A-2 presents a cost comparison of the alternatives.

A.5.2 Alternative 2 - Managed Release

<u>Effectiveness</u>

Over a short-term period (defined as when the ITS is taken off-line until a cap is placed on the Solar Ponds) the Managed Release is a more effective method than no-action of ensuring greater protectiveness for the public and the environment. Water would be held in Pond A-4 until analytical sampling results confirmed that the water could be released. Once the Solar Pond cap was in place then the water would be directly released into the North Walnut Drainage system so its long-term effect would be similar to Alternative 1, No Action. Modeling of the Managed Release Alternative is documented in *Management Plan for the ITS Water* (RMRS, 1996). Table A-3 presents the results of the model. The effectiveness of this alternative is based on the stream standards for North Walnut Creek. On March 3, 1997, the Water Quality Control Commission established a stream standard of 100 mg/L until 2006. The Solar Ponds should be capped by 2006 and contamination going into the drainage basin should decrease. The modeling does not address the reduction in contaminant concentrations due to the Solar Ponds cap which should further reduce the impact of nitrates and uranium when the stream standard for nitrates returns to 10 mg/L.

<u>Implementability</u>

This alternative is highly implementable since it consists of installing a pipeline, monitoring groundwater, and grouting the ITS. This alternative is technically and administratively feasible since the major components like the MSTs and the A-4 Pond are already in place. The line from MSTs to A-4 Pond is no longer in place and will have to be reinstalled. Materials for the pipeline are readily available.

<u>Cost</u>

The cost of the managed Release Alternative is approximately the same as direct release except that an additional capital cost of $40,000 would be incurred to install the pipeline from the MSTs to the A-4 Pond. An annual cost of $10,000 per year was assumed for the labor to sample and manage the system plus sampling equipment and supplies.

Table A-2. Cost Comparison of Solar Pond Plume Alternatives.

Costs	Alternatives				
	Alternative 1- No Action	**Alternative 2 – Managed Release**	**Alternative 3 – Treatment at Building 995**	**Alternative 4 – Phytoremediation**	**Alternative 5 - Reactive Barrier**
Capital Cost	$207,000	$247,000	$134,800	$671,000	$1,250,000
Un-escalated Annual Operation and Maintenance Cost	$0	$10,000	$343,200	$15,000	$10,000
Un-escalated Operation and Maintenance over 25 years	$0	$250,000	$8,580,000	$375,000	$250,000
Escalated Operation and Maintenance Over 25 years	$0	$501,000	$17,199,000	$752,000	$501,000
Total Escalated Cost	$207,000	$748,000	$17,233,800	$1,423,000	$1,751,000
Present Worth	$207,000	$497,000	$8,714,000	$1,046,000	$1,500,000

(For purposes of providing a total cost estimate it was assumed that the project life for each alternative with operations and maintenance costs would be 25 years. An escalation factor of five percent was used. For the present worth calculation, it was assumed that the interest rate and the escalation rate were identical).

Table A-3. Average Predicted Seasonal Water-Quality Values in North Walnut Creek from Proposed ITS Discharge

Season	Average Predicted Nitrate Concentration (mg/L NO_3^- - N)	Average Predicted Uranium Activity (pCi/L)
Dec, Jan, Feb	32	9.7
Mar, Apr, May	20	6.6
Jun, Jul, Aug	35	8.7
Sep, Oct, Nov	18	6.7

A.5.3 Alternative 3 - Treatment at Building 995

Effectiveness

On a short-term basis, treatment at the STP would not be protective of human health and the environment unless it is pretreated to remove uranium. Furthermore, the STP is not set up to treat nitrates. Treatment would include the addition of a methanol feed as a food source to sustain biological reduction of nitrates. Even if treatment for nitrates were added, the STP is not effective as a long-term solution since the 995-treatment system will be shut down as part of RFETS closure. At best, this would be a temporary option. Uranium would need to be captured in the solids recovered through processing and shipped to the Nevada Test Site; STP plans call for land farming of biosolids in which case uranium concentrations in the ITS water are probably too high. The treatment process would discharge water that would continue to meet the NPDES requirements. Because of the nitrate concentrations, there is a potential that the discharge from the STP could be higher than the NPDES requirements. To ensure that the discharge requirements are met, the facility would have to go back to round-the-clock operation.

Implementability

Even if existing piping is sound, this option would still require redesign and construction of the STP.. Impacts to Preble's Mouse habitat would be very minimal.

Cost

Utilizing existing piping would cost about $16,000 in capital costs which assumes that a major modification would not be required. The cost to modify the STP is the remainder of the capital cost of $134,800. Operation of the STP is about $343,200 for the yearly flow of three million gallons. An additional cost could be incurred in disposing of the biosolids. Because of the magnitude of the annual, costs this alternative had the highest total escalated cost as well as the highest present worth cost. It should be noted that at some point in time the sanitary sewer system would not be operation, at which time additional costs could be incurred to continue to provide treatment.

A.5.4 Alternative 4 - Phytoremediation

Effectiveness

Alternative 4- Phytoremediation would only address approximately one third of the nitrate loading currently being addressed by the ITS. This removal rate is the peak of the phytoremediation system effectiveness

76

since a startup period of about four years would be required before peak performance is seen. This removal rate is not high enough to effectively protect the public health and environment. Furthermore, this alternative would be detrimental to Preble's Mouse Habitat, which would fall under the Endangered Species Act as an ARAR which makes this alternative unsuitable as either a short-term or long-term solution.

Implementability

As noted above, although it is technically feasible, the alternative has low implementability because of potential impacts to Preble's Mouse Habitat.

Cost

The capital costs are $671,000 for establishing a phytoremediation system. Closure costs for the ITS were not included. Operation and maintenance (annual costs) were estimated to be about $15,000.

A.5.5 Alternative 5 - Reactive Barrier

Effectiveness

This alternative offers a combination of both short-term and long-term benefits. The reactive barrier would treat both uranium and nitrate. A quantitative removal efficiency will be evaluated as part of a treatability study. This alternative offers the greatest degree of long-term protectiveness to the public, workers, and the environment.

Implementability

The reactive barrier would be placed north of the road which is considered outside of Preble's Mouse habitat and therefore will have minimal impacts. If installed, a passive treatment system to address the ITS water would be closer to the habitat area and precautions would be necessary. This is an available technology; however, treatability testing is needed to develop design parameters for the reactive barrier and to evaluate options for the ITS water.

Cost

The capital cost was based on a cost of $1,070,000 to install the reactive barrier based on previous estimates for the East Trenches Plume. For cost estimating purposes, it was assumed that a passive treatment system would be placed at the ITS sump to treat nitrates. The capital cost of this system was estimated to be $150,000 plus $30,000 for paving the portions of the ITS yielding a total capital cost of $1,220,000. Operation and Maintenance costs were estimated to be about $10,000 per year with operation continuing past site closure. Costs for replacing the reactive media were not included since, although the life of the reactive media is not known, it could be outside the period of 25 years used for cost estimation purposes.

A.5.6 Alternative Selection

Alternative 5, Reactive Barrier is recommended as the most suitable alternative to ensure both protectiveness and long-term operation. The three key criteria in this decision were impact to Preble's

11

Mouse habitat, the ability to operate passively over an extended period of time, and the ability to address contaminants of concern. Ultimately, cost did not play an important factor in the alternative selection process because the other alternatives had fatal flaws. Alternative 1, No Action is likely to increase nitrate concentrations because operation of the ITS would be discontinued. Reducing the existing degree of protectiveness was considered a fatal flaw and this alternative was not selected. Alternative 3, Treatment of ITS water at Building 995 was not a long-term solution and creates problems for the STP even as a short-term solution. Alternative 4, Phytoremediation was not effective and was too damaging to the existing ecological habitat. If Site conditions could have supported more trees and there was not a threatened species on Site, then this alternative would be considered in a more favorable light.

Alternative 2, Managed Release, is the best alternative to installing a reactive barrier but based on informal input was not viewed favorably by the regulatory agencies. The biggest drawback is that Managed Release relied on changes in how surface water is managed and compliance is maintained. It does offer many benefits, including little impact to Preble's Mouse habitat, low cost, and it is a long-term solution.

Alternative 5, Reactive Barriers, although relatively costly would provide the greatest level of groundwater treatment of all the alternatives. It is recommended for the following reasons:

- Nitrates would be reduced.
- It offers the greatest degree of protectiveness.
- It would have very minimal impacts to Preble's Mouse habitat.
- Most of the disruption during installation will occur outside the habitat area.
- It is a long-term solution.
- It does not require elements of the RFETS infrastructure that are likely to be abandoned.
- The technology is available and has become more established.
- Groundwater flow can be restored to its natural discharge point in the drainage system (i.e., under natural conditions, groundwater discharges to the North Walnut Creek drainage at the base of the hill slope).
- It offers the greatest degree of flexibility
- The reactive barrier is passive and low maintenance.
- Uranium would be removed.

18

Table A-3. Overall Comparison of Alternatives[1]

Criteria	ALTERNATIVES				
	Alternative 1- No Action	**Alternative 2 - Managed Release**	**Alternative 3 - Treatment at Building 995**	**Alternative 4 – Phytoremediation**	**Alternative 5 - Reactive Barrier**
Effectiveness	**Not Effective –** Nitrate concentrations would increase and exceed ARARs for North Walnut Creek	**Moderate -** Provides good short-term protection since water would be analyzed prior to release.	**Not Effective -** STP cannot handle high loading due to precipitation events. Uranium is not addressed if biosolids are to be land farmed. This is not a long-term alternative because the STP will be closed down.	**Low -** Could only address one third of the current ITS liquid waste stream.	**Good-** uranium is treated and water is denitrified to ensure applicable surface water standards are met.
Implementability	**High –** This alternative would require little effort other than closure of the ITS.	**Low -** The technology is readily available. Implementation would consist of installing additional lines and decommissioning the ITS. Highly dependent on surface water ARARs and a point of compliance downstream of A-4 Pond.	**Low –** This would be very implementable as long as biosolids continued to be sent to Nevada Test Site; however, it is dependent on continued operation of the STP.	**Low –** Impediments to implementability construction in Preble's Mouse habitat must be approved by USFWS	**Moderate -** Reactive barriers have become a more prevalent technology. It is possible to implement with minimal impact to Preble's Mouse habitat.
Cost	**Cost=$207,000** **Low Cost-** The cost is low because no treatment would be implemented to address the plume.	**Cost-$748,000** **Moderate Cost-** Cost-effective due to both low capital and annual costs	**Cost = $17,233,800** **High Cost-** High annual costs made this the most costly alternative	**Cost = $1,046,000** **Moderate Cost –** Annual costs are relatively low	**Cost = $1,752,000** **Moderate Cost-** This alternative had the highest capital costs but low annual cost.

[1]Consistent with the Implementation Guidance Document, the purpose of the overall comparison is to rank, on a semi-quantitative basis (i.e., low, moderate, high), so that a recommended alternative may be selected.

Best Available Copy

79/79

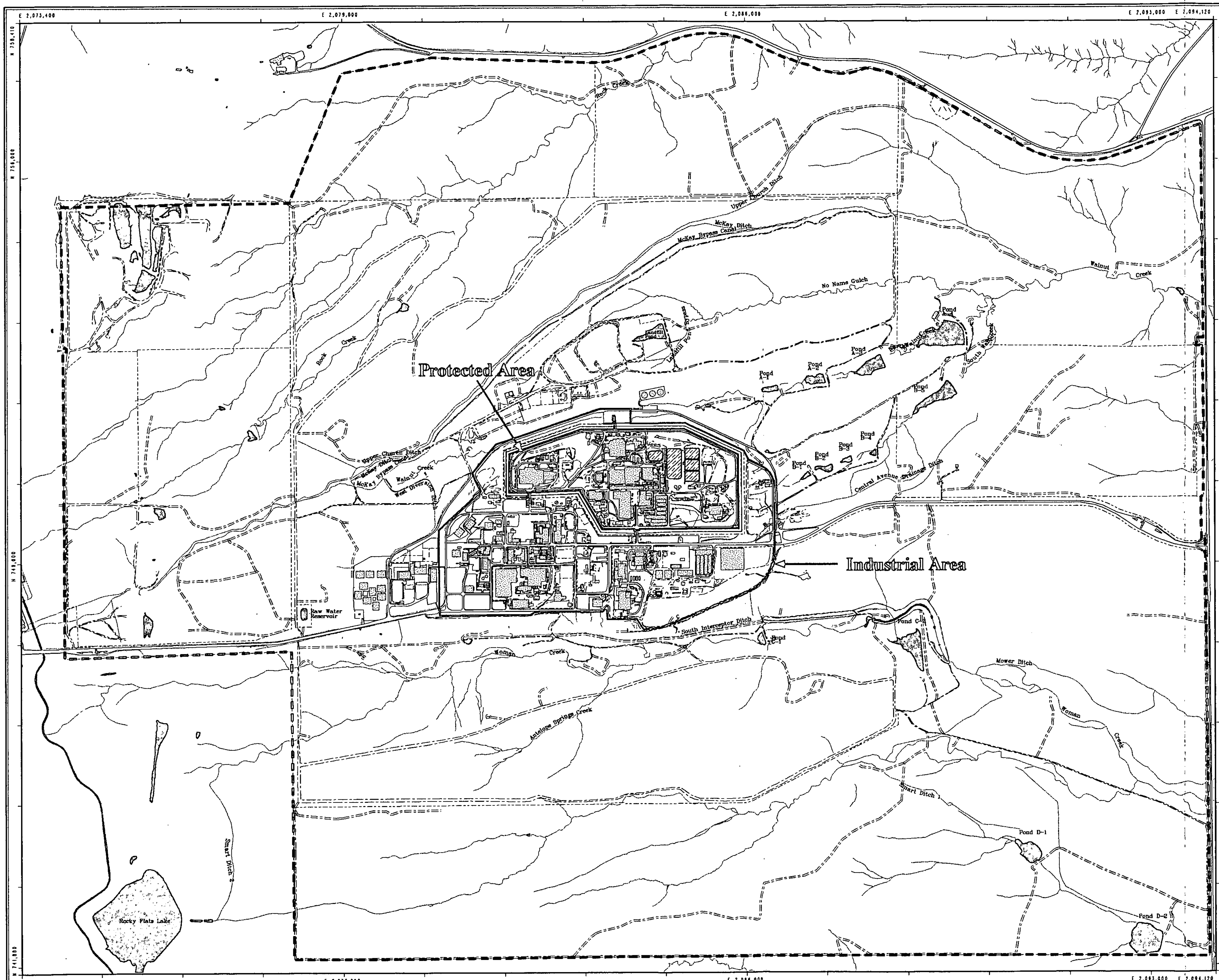


Figure 1-1

Site Location Map
Solar Ponds Plume

EXPLANATION

Standard Map Features

- Buildings and other structures
- Solar evaporation ponds
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Rocky Flats boundary
- Paved roads
- Dirt roads

DATA SOURCE: Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95

Scale = 1 : 20450
1 inch represents approximately 1704 feet

500 0 1000 2000ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:

RMRS Rocky Mountain Remediation Services, L.L.C.
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 464
Golden, CO 80402-0464

MAP ID: 99-0294 May 27, 1999

NT_Svr w:/projects/fy99/99-0294/sitemap/sitemap99.aml

9

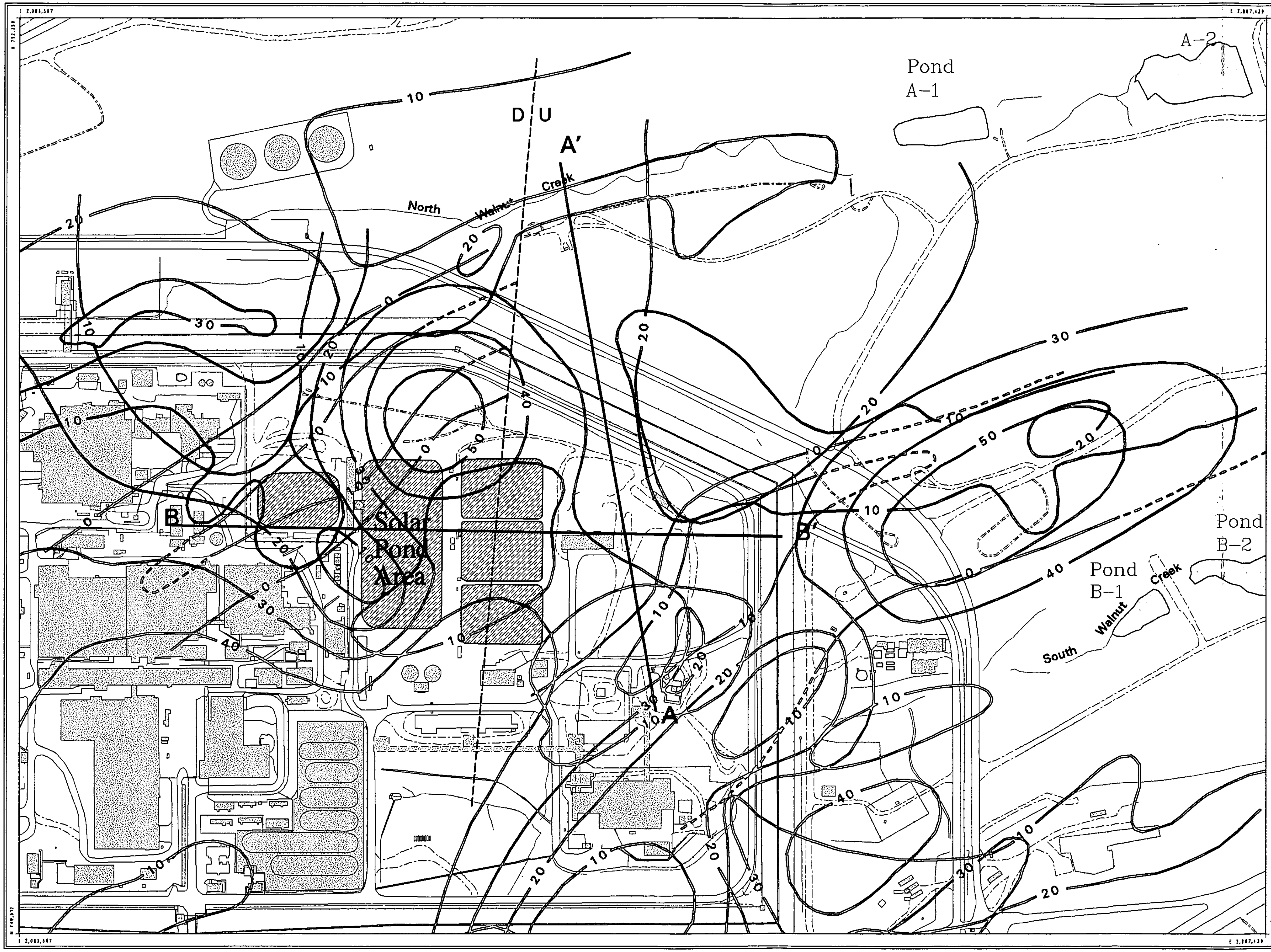


Figure 2-1

Isopach of Unconsolidated Deposits and Weathered Bedrock and approximatelocation of Cross-Sections A-A' B-B' Solar Ponds Plume

LEGEND

- Isopach of Unconsolidated Deposits
- Isopach of Weathered Bedrock
- Arapahoe Channel Deposits
- Suspect Fault

Standard Map Features

- Buildings and other structures
- Solar evaporation ponds
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Paved roads
- Dirt roads

N

Scale = 1 : 3860
1 inch represents approximately 322 feet

100 0 200 400ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:

RMRS Rocky Mountain Remediation Services, L.L.C.
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 464
Golden, CO 80402-0464

MAP ID: 98-0245

December 16, 1998

/gis2/projects/fy98/98-0245/isopach/isopach-fig3-10.aml

12

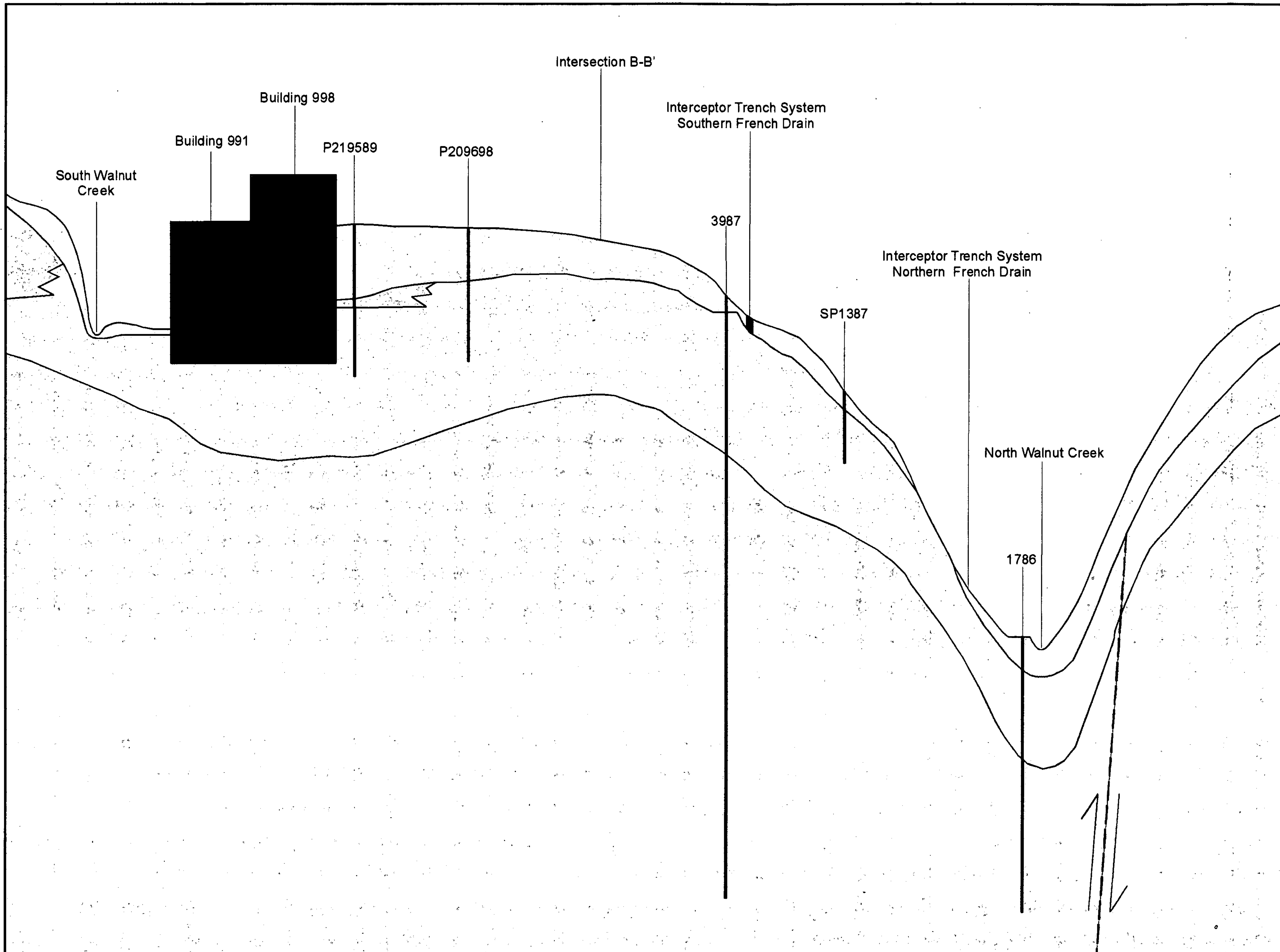


Figure 2-2
Cross-Section A-A'
Solar Ponds Plume

Generalized Building Profile
Unconsolidated Surficial Deposits
Weathered Arapahoe or Laramie Formation
Unweathered Arapahoe or Laramie Formation
Arapahoe Formation Channel Desposits
Location of Inferred Fault

1" = 222' Horizontally
1" = 22' Vertically
Vertical Exaggeration (10:1)

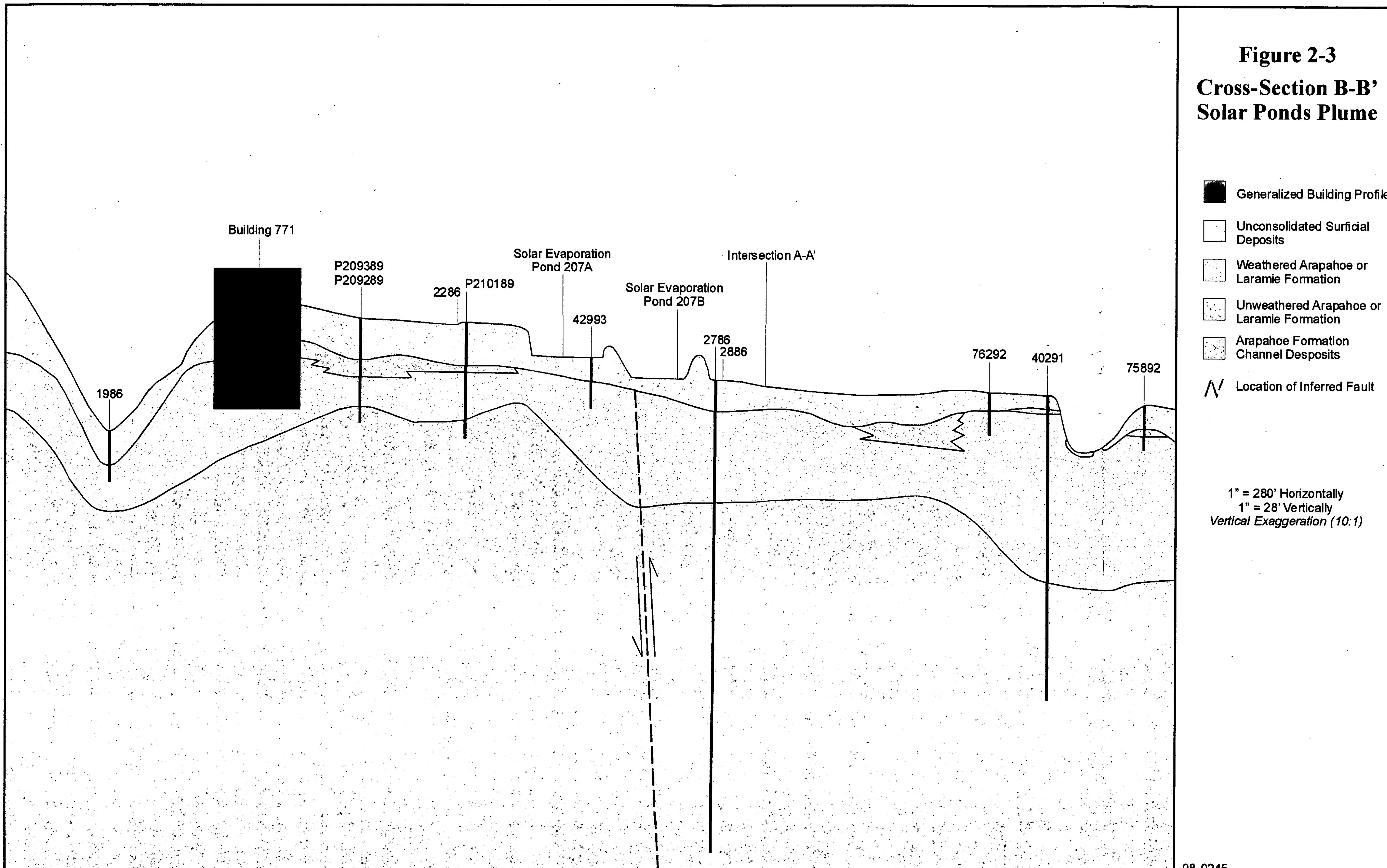


Figure 2-3
Cross-Section B-B'
Solar Ponds Plume

98-0245

14

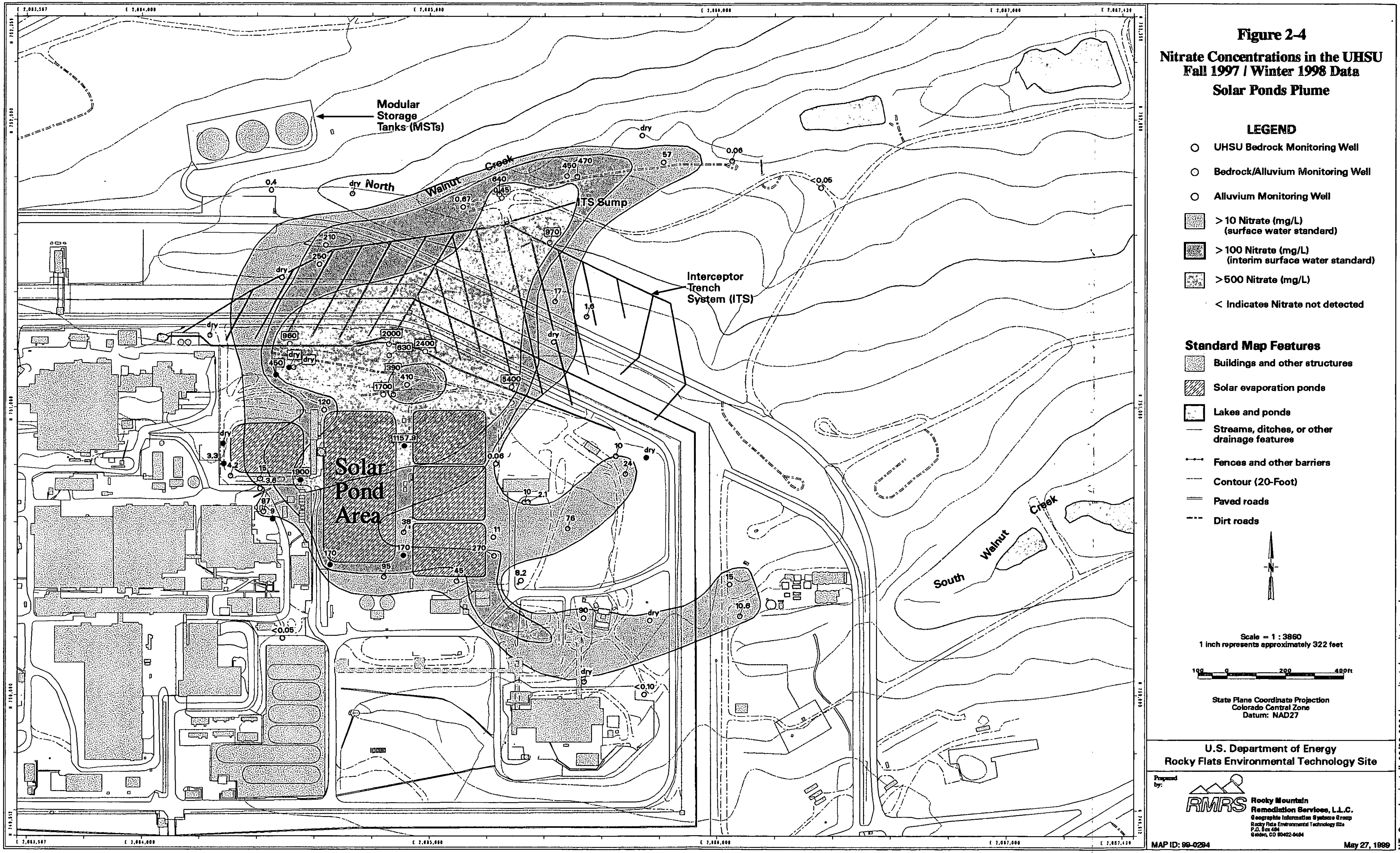
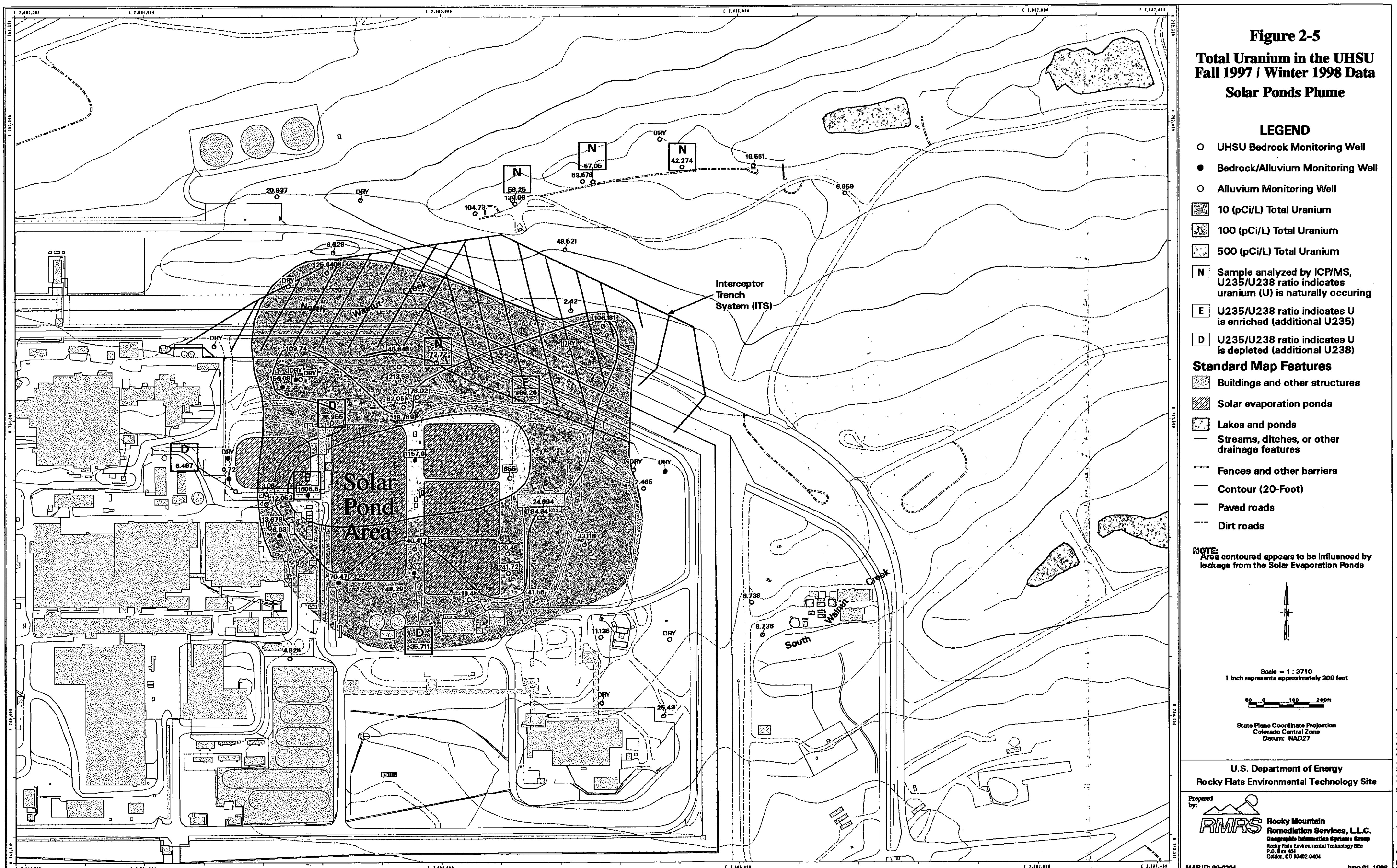


Figure 2-4
Nitrate Concentrations in the UHSU
Fall 1997 / Winter 1998 Data
Solar Ponds Plume
LEGEND
UHSU Bedrock Monitoring Well
Bedrock/Alluvium Monitoring Well
Alluvium Monitoring Well
> 10 Nitrate (mg/L) (surface water standard)
> 100 Nitrate (mg/L) (interim surface water standard)
>500 Nitrate (mg/L)
< Indicates Nitrate not detected
Standard Map Features
Buildings and other structures
Solar evaporation ponds
Lakes and ponds
Streams, ditches, or other drainage features
Fences and other barriers
Contour (20-Foot)
Paved roads
Dirt roads
N
Scale = 1 : 3860
1 inch represents approximately 322 feet
State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27
U.S. Department of Energy
Rocky Flats Environmental Technology Site
Prepared by:
RMRS
Rocky Mountain Remediation Services, L.L.C.
MAP ID: 99-0294
May 27, 1999
Modular Storage Tanks (MSTs)
North Walnut Creek
ITS Sump
Interceptor Trench System (ITS)
Solar Pond Area
South Walnut Creek

17



NT_Svr w:/projects/fy98/98-0294/n-u-plume.aml

18

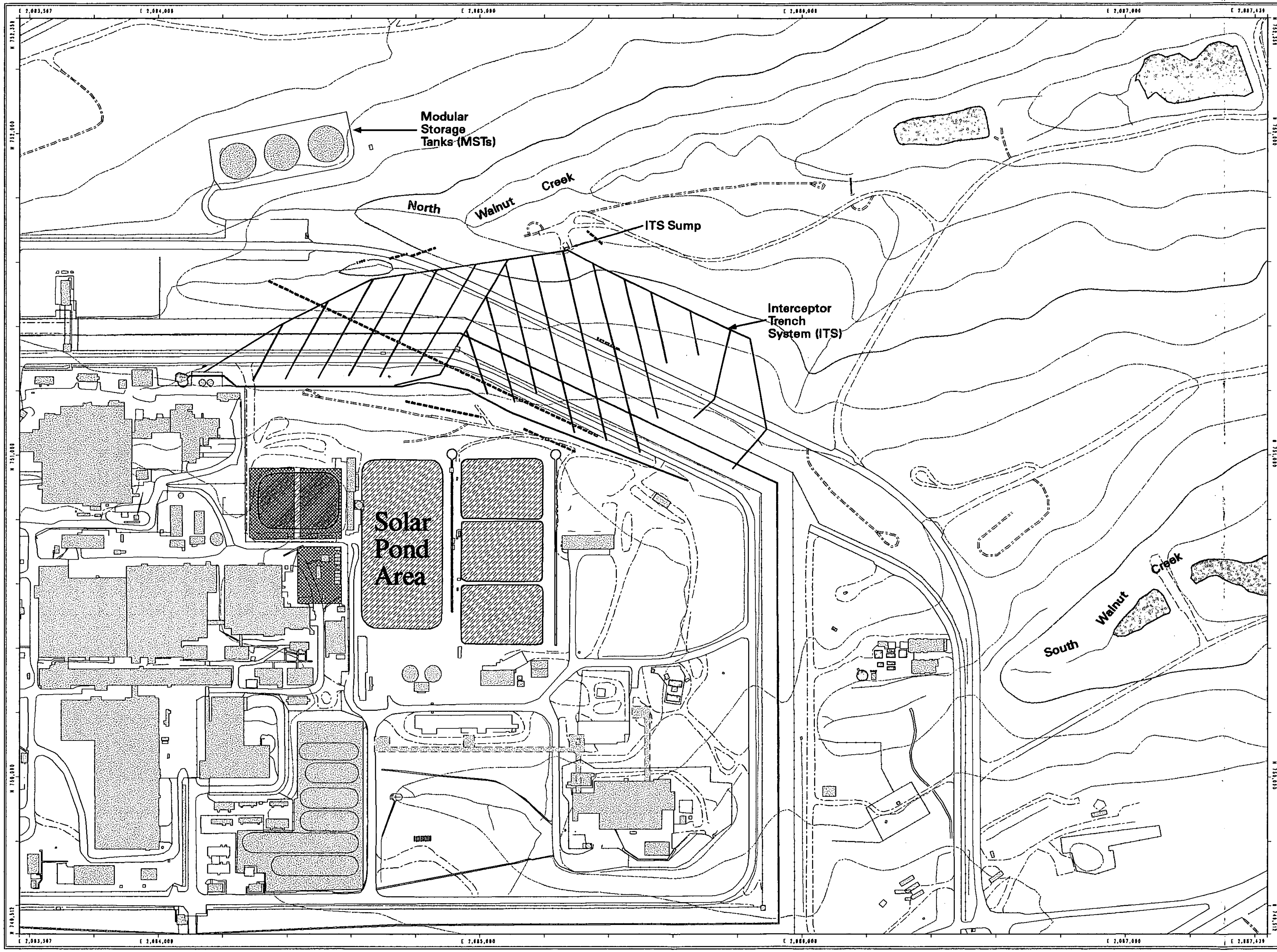


Figure 2-8
Solar Evaporation Ponds and Interceptor Trench System Solar Ponds Plume

EXPLANATION

- Sump Locations
- Original Pond Area
- Former Trenches or French Drains
- Perforated Drainage Tile

Standard Map Features

- Buildings and other structures
- Solar evaporation ponds
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (20-Foot)
- Paved roads
- Dirt roads

Scale = 1 : 3860
1 inch represents approximately 322 feet

100 0 200 400 Ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:
RMRS Rocky Mountain Remediation Services, L.L.C.
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 464
Golden, CO 80402-0464

MAP ID: 99-0294 June 01, 1999

NT_Svr w:/projects/fy99/99-0294/samploc-spond/ponds-trench.aml

24

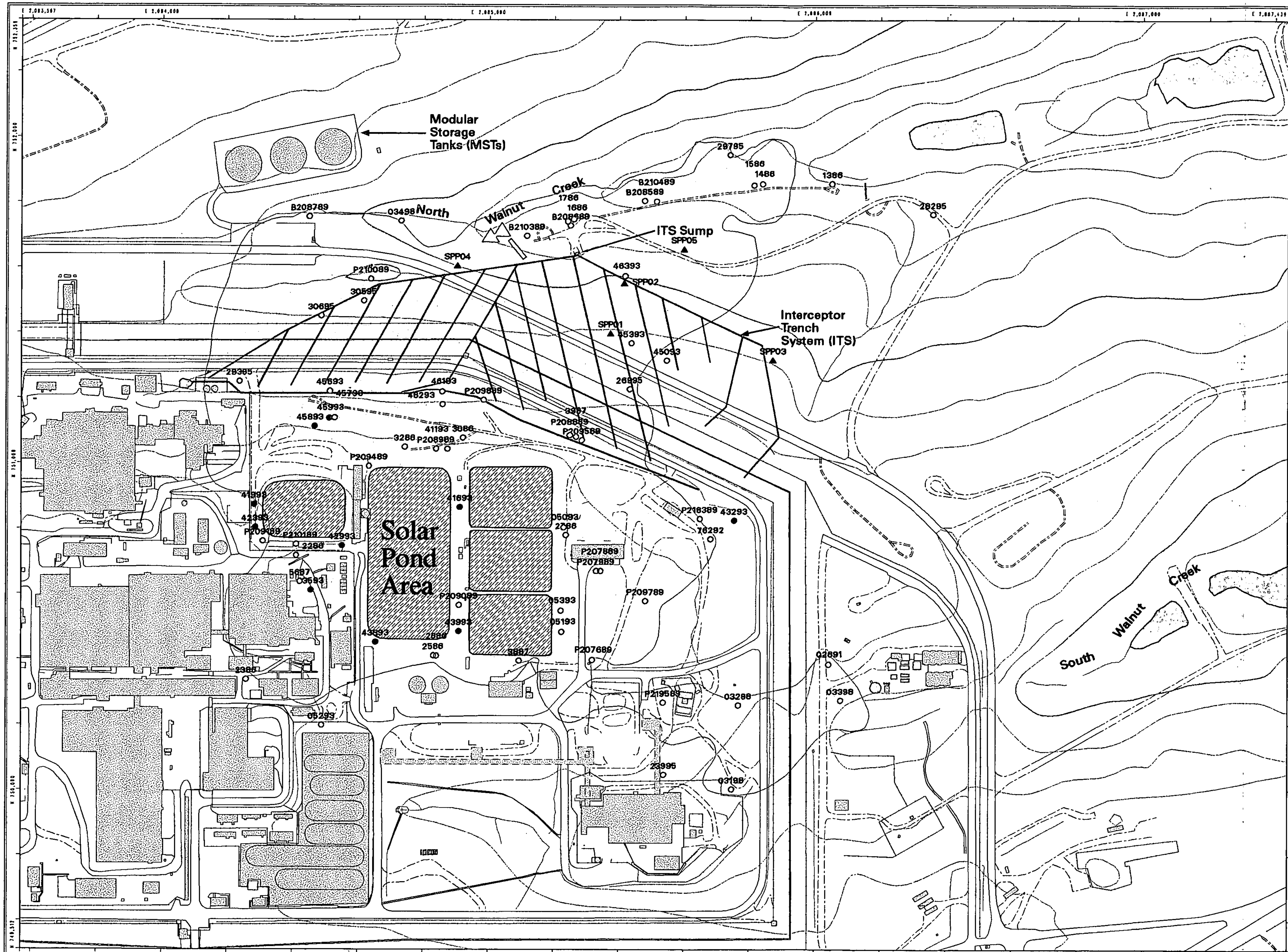


Figure 2-9

1997-1998 Sampling Locations
Solar Ponds Plume

LEGEND

- ▲ Soil Sampling Borehole Location
- ○ LHSU Bedrock Monitoring Well
- ○ UHSU Bedrock Monitoring Well
- ● Bedrock/Alluvium Monitoring Well
- ○ Alluvium Monitoring Well
- △ Vegetation sampling location (tree)
- ▭ Vegetation sampling location transect (grass)
- □ Approximate Extent of SPP Nitrate Plume (greater than 10 mg/l) OU4 Phase 2 Results (1995)

Standard Map Features

- Buildings and other structures
- Solar evaporation ponds
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (20-Foot)
- Paved roads
- Dirt roads

Scale = 1 : 3860
1 inch represents approximately 322 feet

100 0 200 400ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:

RMRS Rocky Mountain Remediation Services, L.L.C.
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 464
Golden, CO 80402-0464

MAP ID: 99-0294 June 01, 1999

NT_Svr w:/projects/fy99/99-0294/samploc-spond/ponds-samp_loc.aml

27

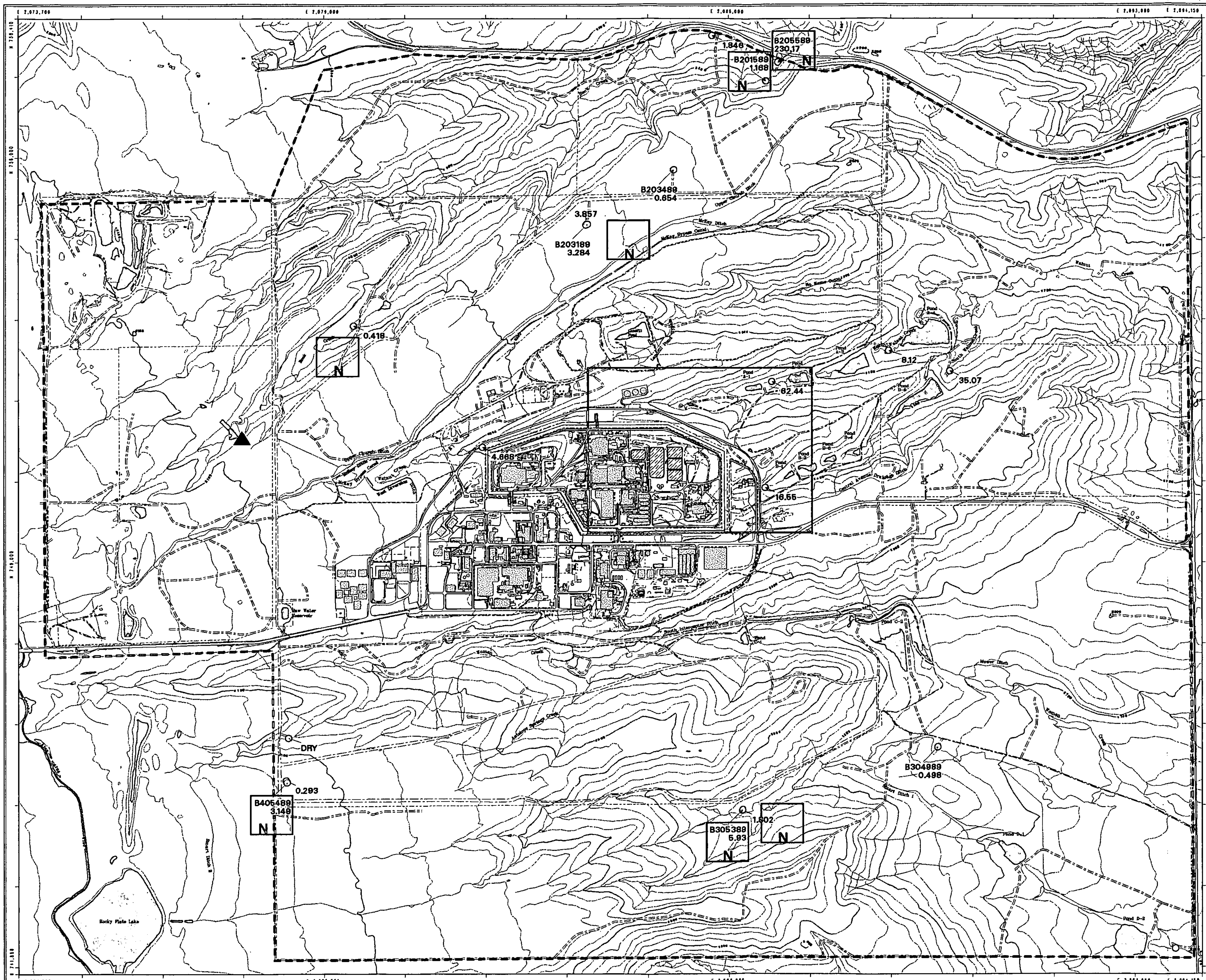


Figure 2-10

1997-1998 Background and Walnut Creek Sampling Locations Solar Ponds Plume

LEGEND

- UHSU Bedrock Monitoring Well
- Alluvium Monitoring Well
- Vegetation sampling location (tree)
- Vegetation sampling location transect (grass)
- N — Sample analyzed by ICP/MS, U235/U238 ratio indicates uranium (U) is naturally occuring

Standard Map Features

- Buildings and other structures
- Solar evaporation ponds
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (20-Foot)
- Rocky Flats boundary
- Paved roads
- Dirt roads

DATA SOURCE:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95
Topology (contours) were derived from digital elevation model (DEM) data by Morrison Knudsen (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~ 10 meter resolution. DEM post-processing performed by MK, Winter 1997.

N

Scale = 1 : 20450
1 inch represents approximately 1704 feet

500 0 1000 2000ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:
RMRS Rocky Mountain Remediation Services, L.L.C.
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 464
Golden, CO 80402-0464

MAP ID: 99-0294 June 01, 1999

NT_Svr w:/projects/fy99/99-0294/bokgrnd-samp/pondo-bok_samp.aml

28

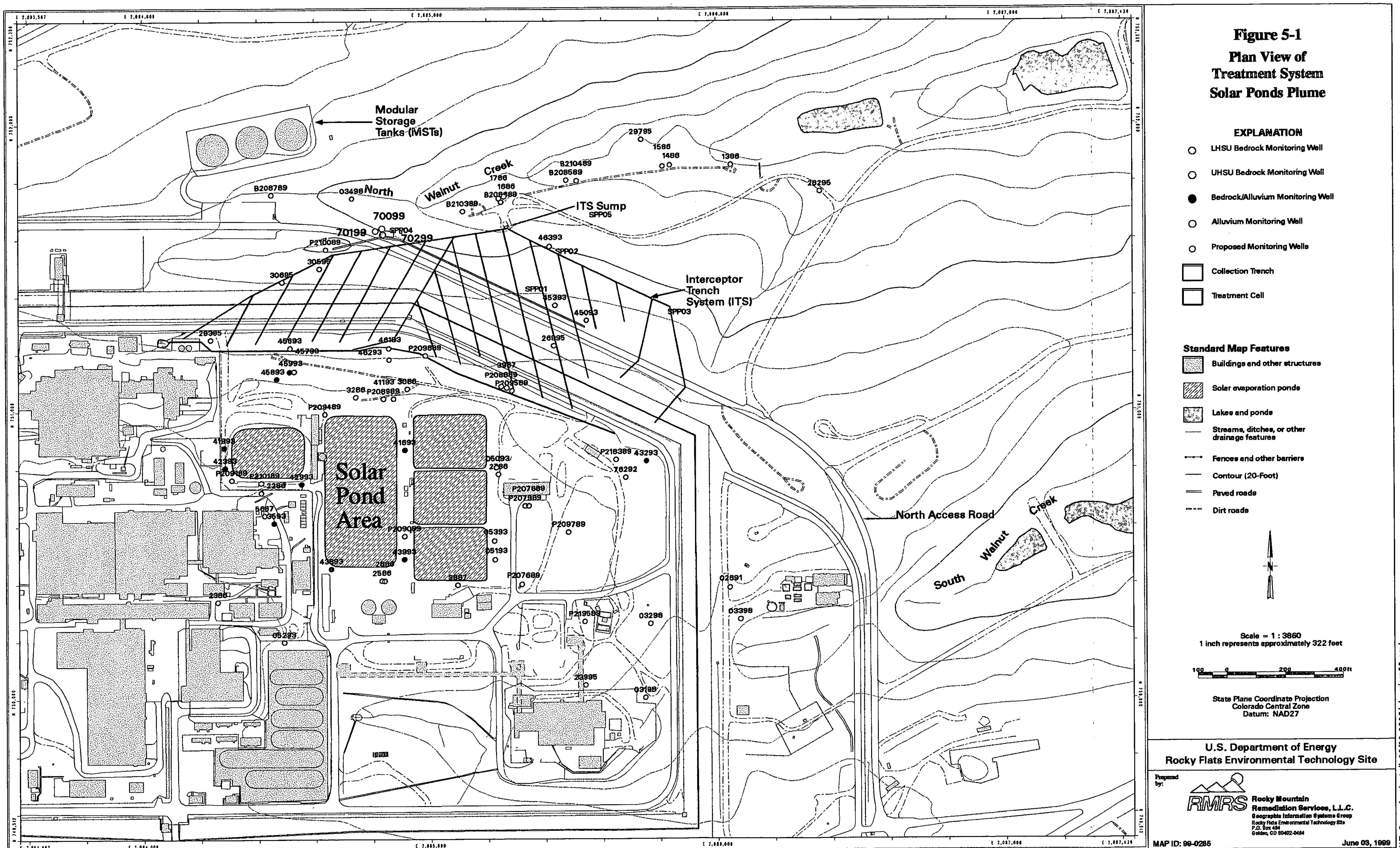


Figure 5-1
Plan View of Treatment System Solar Ponds Plume

50